

AD678546

U. S. ARMY

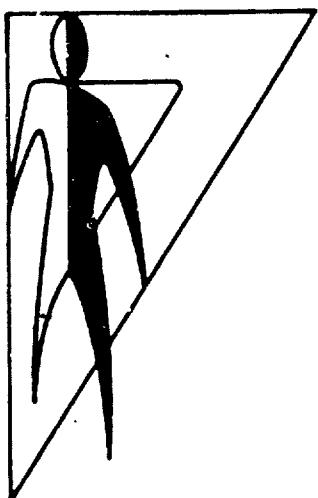
SHORT-TERM MEMORY: AN ANNOTATED BIBLIOGRAPHY

Dennis F. Fisher
Harry F. Wiggins

700
NOV 18 1963
HUMAN ENGINEERING LABORATORIES

August 1968

HUMAN ENGINEERING LABORATORIES



ABERDEEN PROVING GROUND,
MARYLAND

Reproduced by the
CLEARINGHOUSE
for Federal Scientific & Technical
Information Springfield Va. 22151

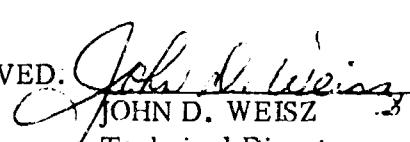
This document has been approved for public
release and sale; its distribution is unlimited.

SHORT-TERM MEMORY: AN ANNOTATED BIBLIOGRAPHY

Dennis F. Fisher
Harry F. Wiggins

August 1968

APPROVED:


JOHN D. WEISZ
Technical Director
Human Engineering Laboratories

U. S. ARMY HUMAN ENGINEERING LABORATORIES
Aberdeen Proving Ground, Maryland

This document has been approved for public
release and sale; its distribution is unlimited.

ABSTRACT

The bibliography is an annotated compilation of 435 references dealing with short-term memory. The period of time from 1959 to June 1968 (present) has accounted for the majority of research in this area, and in accord with this, most of the references included herein are from this period. The included references are arranged in alphabetical order by author. An alphabetical index of pertinent parameters of investigation as well as topics of interest is also provided.

INTRODUCTION

During the past few years, we, along with our colleagues, have been engaged in psychological research dealing specifically with short-term memory processes. Immediately apparent was the enormous amount of material written about short-term memory and the great amount of time that must be spent finding this material. For many areas of psychological investigation there are concise bibliographies available that make a literature search much more efficient. The purpose of this bibliography is to provide such a reference for short-term memory.

Although a few papers appeared prior to 1959, the bulk of research in short-term memory has taken place since that time. In keeping with this fact, the vast majority of entries in this bibliography were reported between 1959 and the present.

The number of entries in this bibliography is limited only by the effectiveness of a request for reprints for the specific purpose of this compilation. The specific letter, sent to many of the known researchers in short-term memory, can be found at the end of this document. The authors wish that omissions be made known to them and subsequent reports be sent for future compilation.

The bibliography is an alphabetical listing by author of 435 entries with annotations. The annotations are those of the individual authors of the respective papers and are either the abstract or summary statements from the specific reference. We are not responsible for annotation except where noted. We have elected this method in order to provide the most exact representation of what was reported. Those references included without annotation have been published without abstracts or summary statements or when published, they were considered too long for inclusion. Following the last entry is an alphabetical index by topic which lists the inclosed references by their number of appearance.

It is our belief that the present short-term memory bibliography is the most complete available. The only other known source is a 170 article reference:
Reynolds, D., and Rosenblatt, R. D. Short-term memory: An annotated bibliography. Technical Report 5-13, George Washington University, Human Resources Research Office, December 1965.

The authors wish to thank Dr. R. A. Monty for his patience, tolerance, encouragement and files.

A

1. Aaronson, D. Temporal factors in perception and short-term memory. Psychological Bulletin, 1967, 67, 130-144.

The temporal course of perception may be an important determinant of errors that occur in immediate recall tasks. The studies reviewed suggest that the following factors play an important role in perception and short-term memory: (a) the rate at which stimuli are presented, (b) the duration of the stimuli, (c) pre- and post-stimulus events. Further, the subject's strategies may in part determine (a) the time elapsing before the various perceptual processes are performed on an item or (b) the order in which items are processed.

2. Aborn, M. & Rubenstein, H. Information theory and immediate recall. Journal of Experimental Psychology, 1952, 44, 260-266.

The present paper reports an attempt to investigate the influence of the degree of organization upon the ability of Ss to recall lists of syllables immediately after learning. A group of Ss was made familiar with a small inventory of nonsense syllables and later learned various rules of organization, each set of rules progressively limiting the syllables which could appear. They then tried to memorize passages of between 30-32 syllables chosen in conformity with the rules learned previously. Organizational arrangements employed ranged from random order (high average rate of information) to high organization (low average rate of information).

1. More syllables are correctly recalled from a passage with a lower average rate of information than from a passage with a higher average rate of information.

2. Up to a certain degree of organization, between 2 and 1.5 bits per syllable, the amount of information learned by the Ss was constant.

3. Beyond a certain degree of organization, about 1.5 bits per syllable, the relationship between the quantity of material recalled by Ss and the average rate of information contained in that material tended to become disproportionate. Although an increasingly greater number of syllables was correctly recalled, the total amount of information contained in the syllables was smaller than in the less organized passages.

4. Up to a certain degree of organization, the quantity of material which S can recall can be predicted from a knowledge of the average rate of information of the given passage and S's level of ability as measured in a passage having a different average rate of information.

3. Adams, J. A. & Dijkstra, S. Short-term memory for motor responses. Journal of Experimental Psychology, 1966, 71, 314-318.

Two experiments were conducted on short-term memory for simple linear, graded motor responses, with length of retention interval and number of practice repetitions or reinforcements as basic variables. The spread of retention intervals was from 5 to 120 sec. for both experiments, and number of reinforcements as 1, 3, and 6 in Experiment I and 1, 6, and 15 in Experiment II. Absolute error was the primary performance measure. Both experiments found error to be an increasing function of retention interval. Number of reinforcements was a significant variable only for the wider range of values in Experiment II, with error being a decreasing function of the variable. Results were considered parallel to those of corresponding studies on short-term memory for verbal responses. Interpretation was in terms of a rapidly decaying memory trace that becomes increasingly stable with reinforcement.

4. Anderson, N. S. Poststimulus cuing in immediate memory. Journal of Experimental Psychology, 1960, 60, 216-221.

The experiments investigated the effects of poststimulus cuing on recall of digits in an immediate memory task. Messages of 12 random numbers read in groups of 4 digits each were presented by tape recording. The Ss wrote 4-, 8-, or 12 digits as indicated by the illumination of combinations of three cuing lights. The light cue was presented at various intervals after the last digit was read. The intervals were: 0 sec. (immediately), 5 sec., or 30 sec. in Exp. I and 0 sec., 2 sec., or 4 sec. in Exp. II.

Results indicated that (a) performance was highest when using a post-stimulus cue for recall of only part of the message, (b) performance decreased with a forced delay between the presentation of the message and the cue for recall, and (c) performance was highest for the last group of digits read (recency).

5. Anderson, S. B. & Ross, S. Memory for items in a matrix. American Journal of Psychology, 1955, 68, 595-604.

6. Andreas, B. G. & Deutsch, E. Processes of verbal memorization revealed in correct and erroneous recall of words and paralogs. Psychonomic Science, 1965, 2, 381-382.

Paralog (C-V-C-V-C) distortions of real words were memorized in mixed lists no better than randomly generated paralogs. Reversed words apparently were unrecognized by most Ss. Error patterns permit inferences concerning memory encoding processes.

Ss were asked to return the next day for "another experiment in the series." They were actually given a 24-hr. unaided recall test, with partial credit again being offered for partial successes.

7. Austin, A. W. & Ross, S. Recall of stimulus-items arranged in a square matrix. The American Journal of Psychology, 1956, 69, 668-671.
8. Averbach, E. and Coriell, A. S. Short-term memory in vision. The Bell System Technical Journal, 1961, 40, 309-328.

Experiments are performed that demonstrate some of the functional properties of short-term storage in the visual system, its decay, readout and erasure. Results indicate that the visual process involves a buffer storage which includes an erasure mechanism that is local in character and tends to erase stored information when new information is put in. Storage time appears to be of the order of one-quarter second; storage capacity is more difficult to assess.

9. Averbach, E. & Sperling, G. Short term storage of information in vision. In C. Cherry (Ed.), Information Theory. London: Butterworth & Co., 1960, Pp. 196-211.

The work described in this paper shows that the visual process involves a buffer storage of relatively high capacity that can take in information virtually instantaneously and retain it to permit its relatively slow utilization. By making use of sampling techniques and the erasure characteristics of the storage, the following properties were demonstrated:

- (1) The capacity of the storage is high compared to the 20-25 bits obtained in span of immediate-memory. The experiments showed that 70 bits could be stored, but this is still only a lower bound on the capacity since different arrangements might well have produced higher figures.
- (2) The decay time depends upon pre- and post-exposure conditions as well as on the exposure itself. The measured decays varied from 1/4 sec. to several seconds.
- (3) The spatial resolution of the storage is disturbed when too many letters are put in. A 2 X 8 array is enough to demonstrate this effect.
- (4) The storage is erasable; new information erases previously stored information.
- (5) The storage may be read out rapidly up to about five items, the initial rate during such a reading burst being of the order of 100 items per sec.

B

10. Baddeley, A. D. Immediate memory and the "perception" of letter sequences. The Quarterly Journal of Experimental Psychology, 1964, 16, 364-367.

It is suggested that the relationship observed by Miller, Bruner and Postman (1954) between the redundancy and the accuracy of reproduction of tachistoscopically presented letter sequences is not a perceptual effect as they suggest, but is due to the informational limitations of immediate memory. An experiment is performed which shows an exactly similar relationship between redundancy and number of letters correctly reproduced when exposure time is long enough for the subject to read out, and hence perceive, all the material with complete accuracy. It is concluded that the more redundant the letter sequence and the longer the exposure time, the more effectively the sequence can be coded and the better it will be recalled.

11. Baddeley, A. D. Language-habits, S-R compatibility, and verbal learning. American Journal of Psychology, 1964, 77, 463-468.

It was predicted that pairs of nonsense-syllables which fit together to give a letter-combination occurring frequently in English (compatible pairs) would be learned more rapidly than pairs which combine to give a less probable letter-sequence (incompatible pairs). In Experiment I, eight pairs of syllables were so selected that in one order they formed a compatible pair (e.g. QEM POG), but when reversed became relatively incompatible (POG QEM, MP being more frequent in English than GQ). Experiment II was concerned with serial learning; it used ten 8-item lists, each of which formed a compatible sequence of syllables in one order, but a relatively incompatible sequence when reversed. In both experiments, the compatible material was learned significantly more rapidly than the incompatible. Meaningful associations did not appear to be an important factor in either study. It is suggested that nonsense-syllable learning may be regarded as the acquisition of a motor-skill in which S transfers from his established language-habits to a new sequence of verbal responses. A compatible sequence, being similar to the language in sequential structure allows more positive transfer and is thus learned more readily.

12. Baddeley, A. D. Short-term memory for word sequences as a function of acoustic, semantic and formal similarity. The Quarterly Journal of Experimental Psychology, 1966, 18, 362-365.

Experiment I studied short-term memory (STM) for auditorily presented five word sequences as a function of acoustic and semantic similarity. There was a large adverse effect of acoustic similarity on STM (72.5 per cent) which was significantly greater ($p < 0.001$) than the small (6.3 per cent.) but reliable effect ($p < 0.05$) of semantic similarity.

Experiment II compared STM for sequences of words which had a similar letter structure (formal similarity) but were pronounced differently, with acoustically similar but formally dissimilar words and with control sequences. There was a significant effect of acoustic but not of formal similarity.

Experiment III replicated the acoustic similarity effect found in Experiment I using visual instead of auditory presentation. Again a large and significant effect of acoustic similarity was shown.

13. Baddeley, A. D., Conrad, R., & Thomson, W. E. Letter structure of the English language. Nature, 1960, 186, 414-416.
14. Baddeley, A. D., Conrad, R., & Hull, A. J. Predictability and immediate memory for consonant sequences. The Quarterly Journal of Experimental Psychology, 1965, 17, 175-177.

Two measures which have been shown to predict the ease of learning trigrams, namely log letter frequency and sequential predictability, were applied to data from an experiment on short term memory. This involved the immediate recall of 120 six-letter consonant sequences which were presented visually one letter at a time. A significant correlation was found between the probability that a given sequence would be recalled correctly and both its mean log letter frequency ($r = 0.308$, $p < 0.001$), and its mean predictability ($r = 0.393$, $p < 0.001$). Partial correlation showed only a marginally significant effect of log letter frequency when predictability was partialled out ($r = 0.161$, $0.05 < p < 0.1$). With log letter frequency partialled out, however, a reliable correlation between predictability and recall score remained ($r = 0.300$, $p < 0.001$).

15. Baddeley, A. D. & Dale, H. C. A. The effect of semantic similarity on retroactive interference in long- and short-term memory. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 417-420.

Experiment I showed RI effects in long-term memory for pairs of adjectives in the classical RI paradigm (Learn A-B, Learn A'-C, Restest A-B, where A and A' are adjectives with similar meanings). Experiment II tried to show comparable RI effects in short-term memory. Sequences of three pairs were presented once and tested immediately. As in Exp. I, pairs of adjectives were used, with experimental trials containing pairs with semantically similar stimuli and control trials comprising pairs with dissimilar stimuli. There was no significant difference between recall of RI items and their controls. Experiment III extended this study to lists of 2, 4 and 6 pairs. Again there was no reliable evidence for RI effects of the type shown in long-term memory.

16. Bartz, W. H. Short-term memory for sequential tasks: The effects of strategy instructions, interpolated tasks, and repeated presentations. Paper read at Midwestern Psychological Association, Chicago, April 1965.

17. Battig, W. F. & Brackett, H. R. Comparison of anticipation and recall methods in paired-associate learning. Psychological Report, 1961, 9, 59-65.

Each of 40 Ss learned two lists of shape-number pairs, one under the traditional anticipation method, the other under a recall method in which the presentation of the pairs and of the stimuli alone for recall represented temporally discrete series. Performance under the recall method was markedly superior to that under the anticipation method. Since a principal difference between the two methods lies in the fact that the immediate knowledge of results provided by the anticipation method is absent under the recall method, the results present difficulties for reinforcement principles as applied to complex human learning, and raise serious questions as to the general usefulness of the type of teaching machine currently on the market.

18. Bjork, R., LaBerge, D., & Legrand, R. The modification of short-term memory through instructions to forget. Psychonomic Science, 1968, 10 (2), 55-56.

This study was designed to investigate whether Ss could reduce the proactive interference of a first verbal item (CCCC) if they were signalled just prior to the presentation of a second item that they could forget the first item. Recall of the second of two CCCC items inserted in a series of digits was better when Ss were told to "drop" the first item than when there was no such instruction, but it was not as good as recall when only one item was presented.

19. Blackwood, R. O. & Link, J. M. A method for observing rehearsal and natural language mediation in short-term memory. Psychonomic Science, 1968, 10 (8), 287-289.

In a short-term memory (STM) study a modified "think aloud" method, using automated operant conditioning with points as reinforcers, effectively suppressed covert rehearsal but permitted overt rehearsal. Recall efficiency under modified think aloud conditions, with rehearsal and natural language mediators observable, did not differ significantly from recall efficiency under the silent condition. The new method may make possible observation of verbal mediation in STM and other verbal learning experiments.

20. Blankenship, A. B. Memory span: a review of the literature. Psychological Bulletin, 1938, 35, 1-25.

Though 146 references are listed in the bibliography, it is appalling to note how little real knowledge there is in the field of memory span. Practically all of the questions raised in the present paper have to remain unanswered; many researches have been undertaken, but few facts have been proved.

It has been pointed out throughout the paper that the primary causes for this state of affairs are the widely diverse methods of administering the test, the many kinds of materials used, the different groups of subjects used, the methods of

scoring, etc. The question of whether or not memory span is a specific ability is essential: the effect of other factors cannot be answered until this is determined. For if memory span is a specific ability, it seems obvious that investigators using different materials and methods can expect only to get different answers to the same questions.

Probably the one thing most experimenters do agree on is a functional definition of memory span. But for other questions there are all sorts of answers. We do not know whether memory span is a specific or a general trait. We are sure that memory span is affected by certain extrinsic and by certain intrinsic factors, but we are not sure just what to include under each list, since all sorts of results have been claimed for any one variable.

Oddly enough, however, the test has been shown to have a fairly high reliability, and clinical investigators think enough of it seldom to omit it in an examination. It is favored by clinical investigators because of its close relation to intelligence (which has been fairly definitely shown), its simplicity, its brevity, and its lack of emphasis on language ability.

But, nevertheless, the whole field is wide open for a real experimental attack, for there is not a single aspect of the subject which is a closed chapter.

21. Blick, K. A. Cultural primaries as a source of interference in short-term verbal retention. Journal of Experimental Psychology, 1965, 69, 246-250.

Kent-Rosanoff stimulus words were separated into 3 categories having different cultural probabilities of producing R_1 (primary), R_2 (secondary), or R_{3-n} (sum of R_3 to R_n). The average cultural probabilities of R_1 for the 3 categories were .14, .32, and .73. A proaction design (Training A, Training B, and Test B) with 60 Ss per category was used. Training consisted of a list of 5 R_1 words followed by a list of 5 corresponding R_2 words. After 120 sec. of vowel cancellation, Ss were tested for recall of the R_2 words in the presence of the 5 stimulus words corresponding to the R_1 and R_2 words of training. Intrusions of R_1 words were found to be strongly related to the cultural probability of R_1 . This finding was interpreted as the most solid empirical demonstration we have that language habits can interfere greatly in short-term retention.

22. Borkowski, J. G. Interference effects in short-term memory as a function of level of intelligence. The American Journal of Mental Deficiency, 1965, 70, 458-465.

This study was designed to assess the interaction between proactive interference (PI) and IQ in short-term memory (STM). Results indicated that the decline in STM at long retention intervals (e.g., 15 sec.) was greater for low IQ and retarded groups than for high IQ and MA control groups. It was concluded that individual susceptibilities to PI effects in STM are related to IQ.

23. Borkowski, John G. Distributed practice in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 66-72.

The similarity of short-term memory (STM) to long-term memory (LTM) and acquisition (ACQ) was assessed in terms of the operation of common variables, massed (MP) and distributed practice (DP). Two basic transfer paradigms, A-C and C-B, were used to identify the nature of the interference among four transfer pairs in experimental lists. Control lists were designed so that interpair interference was at a minimum. The first and fourth pairs within each list were presented twice under MP (0 sec) or DP (24 sec) conditions and tested after 0, 15, or 45 sec. In both paradigms, recall of pair four under DP was significantly superior to recall under MP at retention intervals of 15 and 45 sec, irrespective of type of list construction (experimental or control). This result indicates that DP in STM does not operate in an analogous way to DP in LTM or ACQ. Proactive interference was shown to be a major variable in producing decrements associated with STM.

24. Borkowski, J. G. & Eisner, H. C. Meaningfulness and abstractness in short-term memory. Journal of Experimental Psychology, 1968, 76 (1), 57-61.

Three experiments were conducted to investigate the effects of word meaningfulness (m) and abstractness (a) in short-term memory (STM). Recall for sets of words was tested after short (3 or 1 sec.) or long (18 or 20 sec.) retention intervals. The number of sets prior to any recall period defined the amount of proactive interference (PI). Results indicated that abstractness had a significant effect on the course of STM when varied independently of m and frequency. In contrast, m effects were significant only when a was not controlled. The differences in STM for high-m-low-a and low-m-high-a materials were not dependent under the development of PI. Decay of the memory tract as well as PI were considered in attempting to explain the operations of m and a in STM.

25. Bousfield, W. A. & Cowan, T. M. Immediate memory spans for cvc trigrams. Journal of General Psychology, 1964, 70, 283-293.

Immediate memory spans were obtained for groups of homogeneously meaningful CVC trigrams selected so as to sample the entire range of Archer's norms. The items at the lowest level were nonsense syllables of the lowest possible association value. At the opposite extreme were highly meaningful three-letter words. The design of the study involved the use of two types of instruction, the first calling for the ordering of recall and the second calling for free recall. For each type of instruction there were two modes of recall: namely, spelling and pronunciation. The Ss were four groups of undergraduates, one group for each of the experimental conditions. The data indicated that pronunciation yielded appreciably higher memory spans than spelling. There were no differences in the magnitudes of memory spans attributable to the change in instructions from those calling for ordered recall to those calling for free recall. In spite of the freedom permitted in the instructions for free recall, the Ss tended to reproduce the items in the order of their presentation. The functional relationship between the spans and the levels of mean-

ingfulness was linear for the Ss who pronounced the trigrams in their recall. On the other hand, there was an apparent tendency for the spans to increase with meaningfulness at a positively accelerated rate when the Ss spelled the items. An attempt is made to relate these findings to a group of tenable theoretical assumptions.

26. Bower, G. H. & Bostrom A. Absence of within-list PI and RI in short-term recognition memory. Psychonomic Science, 1968, 10(6), 211-212.

Tests were conducted for specific retroactive and proactive interference in short-term recognition memory for paired-associates. Ss studied a set of 17 bigram-digit pairs, some bearing an A-B, A-C relation to each other, some an A-B, A-B relation, and some were A-B, D-C control items. Following one study trial, S rated selected pairs (half correct, half incorrect) according to his confidence that the pair had been presented in the study lists. Repetition items were recognized better than the others, but the RI and PI items were recognized with the same accuracy as their respective controls. The results suggest that the A-B and A-C pairs are stored independently, and that recognition of either pair is by comparison to a common criterion of strength, independent of other associates to the stimulus term.

27. Bregman, A. S. Is recognition memory all-or-none? Journal of Verbal Learning and Verbal Behavior, 1966, 5, 1-6.

The retention of partial information concerning paired associates was shown as follows. After one paired presentation of either short word-short word pairs or simple design single letter pairs, adult Ss were provided with all the stimuli and responses and asked to match them. They were then asked to give a second guess by rearranging only the pairings that had been wrong on the 1st guess. Better-than-chance matching on the 2nd guess showed that some information about the pairings was present in spite of the error on the 1st guess. The results disconfirm the idea that connections among short words, single letters or conventional designs must be learned all-or-none in a recognition task.

28. Bregman, A. S. & Chambers, D. W. All-or-none learning of attributes. Journal of Experimental Psychology, 1966, 71, 785-793.

Partial learning may simply involve attributes (descriptions) of the material being learned all-or-none. An experiment, therefore, biased 41 college student Ss in favor of encoding visual displays in terms of 3 experimentally defined attributes. After Ss reconstructed a group of such visual figures out of a fixed set of component attributes, they were told which attributes had been incorrectly assigned and were given a second guess. Where Ss had indeed encoded the figures in terms of the 3 attributes, 2nd guesses were random. When they did not, 2nd guesses contained information ($p = .01$). The results are interpreted to mean that attributes are either learned all-or-none, or cross a threshold in an all-or-none fashion.

29. Brelsford, J., Jr., Freund, R. & Rundus, D. Recency judgments in a short-term memory task. Psychonomic Science, 1967, 8(6), 247-248.

On each trial of a short-term memory task, Ss were required to give the correct response to a paired-associate stimulus and to estimate the number of trials intervening between study and test on that stimulus. On trials where an incorrect paired-associate response was made, judgment of the number of intervening items was relatively independent of the actual number of intervening items. On trials where a correct paired-associate response was made, judgment of the number of intervening items was accurate for recent items but incorrect for more distant items.

30. Broadbent, D. E. Short-term memory. New Scientist, 1962, 16, 20-21.
31. Broadbent, D. E. Techniques in the study of short-term memory. Acta Psychologica, 1965, 24, 220-233.
32. Broadbent, D. E. Recent analysis of short-term memory. Symposium on "Short-Term and Long-Term Memory" at International Congress of Psychology, Moscow, U.S.S.R., August, 1966.
33. Brown, J. Some tests of the decay theory of immediate memory. Quarterly Journal of Experimental Psychology, 1958, 10, 12-21.

The hypothesis of decay of the memory trace as a cause of forgetting has been unpopular. The reasons for this unpopularity are criticized and a theory of the memory span, based on this hypothesis, is put forward. Three experiments which test the hypothesis are described. In each, two kinds of stimuli are presented to the subject, viz., "required" stimuli, which he attempts to remember, and "additional" stimuli, to which he merely makes responses. The first experiment will show that even when the number of required stimuli is well below the memory span, forgetting occurs if the presentation of additional stimuli delays recall for several seconds. The second shows that the effect of the additional stimuli depends only slightly on their similarity to the required stimuli: it also shows that their effect is negligible when they precede, instead of follow, the required stimuli. The third shows that the effect of additional stimuli interpolated before recall remains considerable even when there is an interval of several seconds between presentation of required and additional stimuli.

34. Brown, J. Information, redundancy, and decay of the memory trace. Mechanization of thought processes. Proceedings of a symposium held at the National Physical Laboratory on 24-27 November, 1958. (National Physical Laboratory Symposium No. 10) London: Her Majesty's Stationery Office, 1959, Vol. 2, Pp. 731-745.

A new form of an old theory of memory will be elaborated. The essence of the theory is that the memory trace is subject to decay (decrease in the signal-to-noise ratio) but that the effect of decay depends (1) on the amount of initial redundancy in the trace, (2) on the coding of information in the trace, (3) on the information available from other traces. With appropriate assumptions, the theory seems able to provide possible explanations of many of the rather complex facts of human learning and forgetting. The paper will include a discussion of the nature of the memory span.

35. Brown, J. Short-term memory. British Medical Bulletin, 1964, 20, 8-11.

1. Possible mechanism.
2. Possible causes of forgetting.
3. Decay of the memory trace.
4. Interference with the memory trace.
5. Inaccessibility of the memory trace.
6. Is there a special short-term store?
7. Conclusions

36. Bruning, J. L. & Schappe, R. H. Type of interpolated activity and short-term memory. Psychological Reports, 1965, 16, 925-929.

This study was designed to determine the effects of retention interval (0, 4, 8, or 16 sec.), trials, and type of interpolated material (nothing, numbers, consonants, or CVCs) on STM. The results indicated that: (1) retention is inversely related to similarity of rest and interpolated items, and (2) similarity interacts with both length of the retention interval and the number of practice trials.

37. Bruning, J. L. & Schappe, R. H. Type of interpolated activity and short-term memory: a note. Psychological Reports, 1965, 17, 256.

38. Bryden, M. P. The manipulation of strategies of report in dichotic listening. Canadian Journal of Psychology, 1964, 18(2), 126-138.

Three experiments on dichotic listening, using a free recall procedure, were carried out. The first experiment demonstrated that much the same strategies of report are used with words and with numbers. The second experiment indicated that verbal associations between the various elements in the series can influence the recall strategy, while the final experiment showed that the use of the same number on both channels at the same time can lead to a shift from one channel to the other. The experiments provide support for a fading-trace theory of immediate memory, but fail to provide any conclusive evidence to support a concept of switching time. It is suggested that the organization of a set of simultaneously available stimulus traces may be viewed as a retrieval process, dependent upon the spatial, temporal, and associative relations between the traces.

39. Bryk, J. A., & O'Connell, D. C. Immediate recall as a function of grammatical structure and mode of presentation. Psychonomic Science, 1967, 8(10), 437-438.

Immediate written recall of nonsense strings was studied in a 3 by 2 factorial design: structure (none, morphology, morphology and syntax) and mode of presentation (vertical and horizontal). Each S recalled a string to criterion of two errorless trials in at least 10 trials. Measures of recall indicated less trials in at least 10 trials. Measures of recall indicated facilitation by structure in both modes of presentation. Multiple comparisons revealed no differences between the two levels of structure. Serial position of first written response differentiated modes of presentation in the nonstructured condition.

40. Buschke, H. Relative retention in immediate memory determined by the missing scan method. Nature, 1963, 200, 1129-1130.

41. Buschke, H. Impairment of short-term memory. Neurology, 1965, 15, 913-918.

A study of differential impairment of short-term memory is presented, centering about the question of kinds of information stored and retrieved. True serial-order recall, an example of retrieval ordered according to characteristics of presented events, is compared with same-order recall, which is an example of retrieval ordered according to characteristics of the presentation (order). The finding that some brain-damaged patients show differential impairment of same-order recall is interpreted as consistent with the assumption of at least 2 types of short-term memory, although it is not yet clear whether these are 2 types of storage or 2 types of retrieval. In either case it appears that what is retained in short-term storage may be information about how to retrieve another kind of information from long-term storage, and that analysis of memory impairment requires consideration of the kinds of information involved.

42. Buschke, H. Types of immediate memory. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 275-278.

This study compares retrieval from immediate memory by same-order and true serial-order recall. The present findings are consistent with predictions based on the assumption of an order-dependent address storage for same-order recall and a marker storage which is not order dependent for true serial-order recall. Until certain alternative assumptions are evaluated, it is not clear whether these results imply two types of retrieval from a common storage, or two types of storage.

43. Buschke, H. Two kinds of short-term storage. Psychonomic Science, 1967, 8(10), 419-420.

The hypothesis that same-order and natural serial-order recall of numbers use a common short-term storage was tested by requiring either same-order or serial-order recall on two successive presentations of the same sequence. The results show the use of two different short term storages, retaining information which refers to appropriate responses in long-term storage.

44. Buschke, H. Perceiving and encoding two kinds of item-information. Perception and Psychophysics, 1968, 3, 331-335.

Perception and encoding of item-information about the occurrence of simple, well-known events (numbers) for retrieval by either same-order recall or serial-order recall was investigated by specifying kind of recall to be used either before or after perception and encoding. Both same-order and serial-order recall were less when kind of recall was specified after presentation, but serial-order recall decreased more than same-order recall. These results indicate that the same numbers may be perceived differently for same-order or serial-order recall: different kinds of item-information may be encoded either in terms of presentation characteristics (serial position for same-order recall) or event characteristics (ordinal position for serial-order recall).

45. Buschke, H. & Lim, H. Temporal and interactional effects in short-term storage. Perception and Psychophysics, 1967, 2(3), 107-114.

The operation of temporal and interactional processes in short-term storage was studied under conditions which require that information about all items presented be stored and the relative retention of all be evaluated concurrently, but preclude further interference after presentation by testing or retrieval effects. Random sequences of twelve two digit numbers from a known set of thirteen were presented visually at 1, 2, or 4 per sec. for full interval and .25 sec. presentation durations to 15 Ss who reported the missing number that was not presented from the set. For 1/sec. full duration presentations the missing scan serial position error distribution shows a linear decrease in errors from first through last presented items. As rate of presentation increases there is a linear increase in total errors, a linearly increasing primacy effect, and an increase of errors over at least the last half of the sequence such that the error distribution remains linear with the same slope. These findings are compatible with the operation of time dependent interactional and perceptual processes in short-term storage but not with autonomous decay.

46. Bushke, H. & Lim, H. Short-term storage of repetitions of two items. Psychonomic Science, 1967, 7(8), 277-278.

Correct choice of the more frequent of two items presented in random sequence appears to be a function of the absolute, rather than the relative difference in number of repetitions of the items. When the absolute difference was held constant at one or five repetitions, proportions of correct choices remained constant as sequence length increased (and relative difference decreased), and was greater for an absolute difference of five than one. This suggests that such choice may depend on evaluation of the relative values of independent short-term traces for each item.

C

47. Cimbalo, R. S. & Laughery, K. R. Short-term memory: Effects of auditory and visual similarity. Psychonomic Science, 1967, 8 (2), 57-58.

The effects of five variables on short-term memory for letters were studied: Auditory Similarity, Visual Similarity, Presentation Rate, Sequence Length, and Blocks of Trials. Performance varied directly with Presentation Rate and inversely with Sequence Length and Auditory Similarity. Performance improved over blocks with high auditory and high visual similarity, and decreased under the low conditions of these variables. The improvement is attributed to learning to ignore redundant cues and attend to cues that permit discrimination. The decrement is attributed to fatigue and/or waning attention.

48. Clark, H. J. Recognition memory for random shapes as a function of complexity, association value, and delay. Journal of Experimental Psychology, 1965, 69, 590-595.

Twelve groups of 24 Ss each were examined on 2 tests at 3 delays for recognition accuracy of random shapes having 2 levels of complexity and 2 levels of association value (A). A measure of form coding was also taken. Forms of high A were more accurately recognized than forms of low A, and a 2nd recognition test on the same forms resulted in a practice effect for simple but not for complex forms. All delay effects were insignificant. Complex form coding was positively related to A. Simple form coding was infrequent and not related to A. Coding was positively related to recognition accuracy for complex forms only. Conclusions were: (a) Ss probably stored an uncoded image of the entire shape of simple, but not of complex forms; (b) complex forms were presumably remembered by making associations to them.

49. Cohen, B. H. An investigation of recoding in free recall. Journal of Experimental Psychology, 1963, 65, 368-376.

Four studies were conducted to evaluate G. A. Miller's chunk hypothesis. 70-word lists comprising 10 exhaustive and 10 nonexhaustive categories of words were presented for free recall. The results indicated that: (a) whether category recall was inferred from word recall or measured directly, between 10 to 14 categories were represented in recall; (b) significantly more words of exhaustive categories were recalled; (c) the 2 category types were used equally in recall; (d) there was a strong tendency to cluster related words in recall; and (e) an index of interitem associative strength, derived from word association norms, discriminated differences in recall between the 2 category types and was significantly related to within-category recall. The results were interpreted as proving support for Miller's position regarding recoding.

50. Cohen, B. H. Recall of categorized word lists. Journal of Experimental Psychology, 1963, 66, 227-234.

According to Miller's chunk hypothesis, the number of word categories (chunks) represented in the immediate word recall of a list of 20 categories of words should be the same as the number of words recalled from a list of 20 unrelated words. Using a design involving list lengths of 10, 15, and 20 chunks and 3 types of word lists (2 categorized and 1 unrelated), the hypothesis was supported--but only if the lists were matched for total presentation time. An index of interitem associative strength, derived from word association norms, showed significant correlations with within-category word recall but was not related to chunk recall.

51. Cohen, B. H. & Hut, P. A. Learning of responses to stimulus classes and to specific stimuli. Journal of Experimental Psychology, 1963, 66, 274-280.

To test Miller's chunk hypothesis, the performance of Ss who learned a common number response to each of 8 categories of 3 words was compared with that of Ss who learned control lists of 8 word-number pairs. Performance of Ss who learned number responses to Exhaustive word categories, i.e., categories whose 3 words represent all (or nearly all) the words belonging to the category, did not differ significantly from that of control Ss. Performance of Ss who learned number responses to Nonexhaustive word categories, i.e., categories whose 3 words represent a small sample of the words belonging to the category, differed significantly ($p < .001$) from both the control Ss and Ss presented with the Exhaustive categories. The results were interpreted as providing support for Miller's views regarding verbal recoding.

52. Cohen, R. L. The differential effect of stimulus intensity on rehearsed and unrehearsed material in short-term auditory memory. Canadian Journal of Psychology, 1967, 21(4), 277-284.

The effect of varying the stimulus intensity (loudness) on the recall of 9-digit sequences, auditory presented, was investigated using two presentation rates. At 1 digit/sec. and with instructions for 3, 3, and 3 rehearsal grouping, stimulus intensity was found to be a variable only in the case of the last 3 digits, which according to rehearsal instructions were unrehearsed. No effect was found on the first six (rehearsed) digits. At 4 digits/sec., a rate too fast for systematic rehearsal, the stimulus intensity affected the recall of the first six digits as well of the last three. These results are discussed in relation to the question of whether or not the stimulus memory trace and the rehearsal memory trace should be regarded as two separate entities. The question of presentation rate and performance is also briefly discussed.

53. Cohen, R. L. and Johansson, B. S. Some relevant factors in the transfer of material from short-term to long-term memory. The Quarterly Journal of Experimental Psychology, 1967, 19, 300-308.

The relationship between short-term memory (STM) and long-term memory (LTM) for digits was investigated by means of a Hebb-type experiment, viz. a presentation of a series of nine-digit numbers, in which a certain number recurs at intervals. Improvement in performance, with regard to the critical, or recurring, number was found when the rehearsal grouping was three-three-and three, but was absent when there were no opportunities for rehearsal or when the rehearsal strategy was grouping five-and-four or searching for systematic numbers.

However, if an overt recall response was given on each occasion the recurring number was presented, improved performance was found even with rehearsal strategy five-and-four.

The conclusion was drawn that rehearsal is the main transferring mechanism from STM to LTM, with the occurrence of an overt recall response as a subsidiary factor.

54. Cohen, R. L. & Johansson, B. S. The activity trace in immediate memory: A re-evaluation. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 139-143.

Both Hebb and Melton have shown that the ability to repeat a given nine-digit number improved when this number recurred several times in a series of such numbers. Learning had taken place. This improvement was also found by the present authors using approximately the same procedure as Hebb, but only where an overt response was involved. Where no overt response was involved, no improvement in performance was found.

When recognition rather than reproduction was used, some evidence of learning was found in the absence of an overt response, but this result should be treated with caution since the majority of Ss, on their own admission, concentrated on trying to recognize only the first, or the first and the last, digit. The attempted retention of subspan units (first or first and last digit) in immediate memory cannot be compared with that of supraspan units (all nine digits).

55. Cooley, R. K. & McNulty J. A. Recall of individual CCC trigrams over short intervals of time as a function of mode of presentation. Psychonomic Science, 1967, 9 (10), 543-544.

A number of CCC trigrams were presented one at a time to Ss over a period of four days. Using Peterson and Peterson's technique, recall of the items was tested after varying retention intervals. On each day half of the trigrams were presented aurally and the other half visually. Results of the study showed that recall following short retention intervals was better when the mode of presentation was auditory. At longer intervals recall either tended to be better when the items were presented visually or did not differ between the two modes of presentation.

56. Conrad, R. Accuracy of recall using keyset and telephone dial, and the effect of a prefix digit. Journal of Applied Psychology, 1958, 42, 285-288.

A test of immediate memory for eight-digit messages was given to 24 female telephone operators, using four different recall conditions. It was found that the presence of a redundant prefix significantly worsened recall. When the message was transcribed onto a 10-digit keysender, recall was not significantly better than when transcribed onto a telephone dial. But when a prefix digit was introduced, the dial proved to be an inferior method of transcription. It would seem that at about the level of difficulty when more than half the messages would be forgotten, recall would be improved by use of keysender rather than telephone dial.

Recall errors were analyzed digit by digit. All errors could be classified into order errors and omissions. No evidence was found that certain digits would be systematically confused with certain others.

57. Conrad, R. Acoustic confusions in immediate memory. British Journal of Psychology, 1964, 55, 75-84.

Sequences of 5 letters of the alphabet were visually presented for immediate recall to 387 subjects. Errors showed a systematic relationship to original stimuli. This is held to meet a requirement of the decay theory of immediate memory.

The same letter vocabulary was used in a test in which subjects were required to identify the letters spoken against a white noise background. A highly significant correlation was found between letters which confused in the listening test, and letters which confused in recall.

The role of neurological noise in recall is discussed in relation to these results. It is further argued that information theory is inadequate to explain the memory span, since the nature of the stimulus set, which can be defined quantitatively, as well as the information per item, is likely to be a determining factor.

58. Conrad, R. Short-term memory factor in the design of data-entry keyboards: an interface between short-term memory and S-R compatibility. Journal of Applied Psychology, 1966, 50, 353-356.

An experiment on immediate recall of 8-digit sequence was carried out. Mode of recall was via a data-entry keyboard. 2 keyboard layouts were used, 1 of high, 1 of low compatibility. The low-compatibility keyboard required more time for entry and gave more errors. These extra errors were identified as being primarily memory rather than aiming errors. The results are discussed in terms of an interface between short-term memory and S-R compatibility; they are held to support a memory model involving a limited-capacity channel, and a practical design conclusion is suggested.

59. Conrad, R. Interference or decay over short retention intervals? Journal of Verbal Learning and Verbal Behavior, 1967, 6, 49-54.

It is well established that if a formally noninterfering task which minimizes rehearsal is interposed between presentation and recall of a short consonant sequence, recall lessens as retention interval is increased. Superficially, this appears to be a classical example of decay. Keppel and Underwood have proposed an alternative explanation in interference-theory terms suggesting that forgetting in this paradigm is due to proactive interference from extinguished associations from prior trials which recover during the retention interval.

An experiment was carried out which varied retention interval after four consonants had been presented. More forgetting occurred as a result of the longer interval, but the main dependent variable was the nature of "intrusions." For neither the short nor long interval were wrong letters equiprobable, errors tending to be acoustically similar to the correct letter. But the distribution of long-interval errors tended more towards random than did that for the short interval. It is argued that the difference in error distribution between short and long interval is incompatible with the Keppel and Underwood explanation. A modification of decay theory is proposed which regards decay as a loss of discriminative characteristics (in the present case acoustic), and recall as a process involving discrimination of available traces. This model would be supported by the error-distribution data.

60. Conrad, R., Baddeley, A. D., & Hull, A. J. Rate of presentation and the acoustic similarity effect in short-term memory. Psychonomic Science, 1966, 5 (6), 233-234.

Ss attempted to recall sequences of six consonants drawn from either an acoustically similar set (B C D G P Q T V), or from a relatively dissimilar set (H K M P R S W Y). Letters were presented visually at a rate of 60 or 120 letters per minute. Performance was impaired by acoustic similarity ($p < .001$) but there was no effect of rate of presentation and no interaction between rate and similarity. This does not support a limited channel capacity interpretation of the acoustic similarity effect.

61. Conrad, R., Freeman, P. R., & Hull, A. J. Acoustic factors versus language factors in short-term memory. Psychonomic Science, 1965, 3, 57-58.

Forty five Ss recalled 6-consonant sequences immediately after letter by letter visual presentation. The main factor contributing to ease of recall was within-sequence acoustic confusability. Language habits were relatively unimportant. Single-letter language frequency was unrelated to recall; second order effects made a small but significant contribution.

62. Conrad, R. & Hille, B. A. The decay theory of immediate memory and paced recall. Canadian Journal of Psychology, 1958, 12, 1-6.

Immediate memory for 8-digit numbers was tested under novel conditions involving paced and unpaced recall. The method was such that the interval between presentation and recall of digits could be varied without introducing an interpolated task. It was found that increasing the interval between presentation and recall increased errors, that unpaced recall was superior to paced recall, and that fast presentation rate led to fewer errors than slow rate. The findings are interpreted as supporting the theory that in the absence of rehearsal, memory decays rapidly with time.

63. Conrad, R. & Hull, A. J. Information, acoustic confusion and memory span. British Journal of Psychology, 1964, 55, 429-432.

Immediately after visual presentation, subjects were required to recall 6-letter sequences. Sequences were drawn from four vocabularies. There were two 3-letter vocabularies, distinguished by the probability of acoustic confusion within them, and two 9-letter vocabularies similarly distinguished. Memory span is shown to be effectively independent of information per item, and to depend substantially on the probability of acoustic confusion within vocabularies.

64. Conrad, R. & Hull, A. J. The role of the interpolated task in short-term retention. Quarterly Journal of Experimental Psychology, 1966, 18, 266-269.

It has been proposed that a single set of operations based on classical interference theory is adequate to describe the phenomena of both short- and long-term memory. An article by Keppel and Underwood (1962) argues that short-term forgetting is due to proactive interference and, by implication, not a result of trace decay. An experiment which varied retention interval and the nature of the interpolated task, gave results which indicate that when the amount forgotten and the nature of errors are considered, a decay model is supported, the proactive interference suggestion being untenable.

65. Conrad, R. & Hull, A. J. Input modality and the serial position curve in short-term memory. Psychonomic Science, 1968, 10 (4), 135-136.

Results are presented which confirm data already published by Corballis (1966), and Murray, (1966). These show that when a sequence of letters or digits is presented for immediate recall, there is a marked difference in the serial position curve of errors according to whether presentation is auditory or visual. This difference specifically shows as a virtual absence of recency in the visual presentation condition.

66. Corballis, M. C. Rehearsal and decay in short-term serial recall. Unpublished doctoral dissertation, McGill University, 1965.

The roles of rehearsal and decay in immediate serial recall of digits were studied by varying temporal factors. Five experiments, involving a total of 198 Ss, are reported.

Experiment I demonstrated that irregular presentation gave better recall than regular presentation. Experiment II showed that this was probably due to temporal grouping. Experiments III and IV showed that recall was better if interdigit intervals were increased within series than if they were decreased within series. This supported an hypothesis that Ss tend to rehearse early items, as well as later items, while the later items are being presented. This "cumulative rehearsal" hypothesis was further supported by Experiment V, which showed that recall was impaired when Ss vocalized each digit as it was presented, especially when presentation rate was slow.

The results were interpreted by distinguishing between a rehearsed component and an unrehearsed component of short-term memory storage, and assuming that only the unrehearsed component was subject to autonomous decay.

67. Corballis, M. C. Rehearsal and decay in immediate recall of visually and auditorily presented items. Canadian Journal of Psychology, 1966, 20, 43-51.

Immediate recall of 9-digit series was compared under two conditions, one (Condition I) in which interdigit intervals were short at first but were gradually increased within series, and one (Condition D) in which intervals were long at first but gradually decreased. Twenty-four Ss received both conditions in each of two experiments; presentation was visual in the first experiment and aural in the second. Recall was better for Condition I in Experiment 1 supporting a hypothesis that Ss rehearsed cumulatively during visual presentation of digits. Experiment 2 failed to show any consistent difference between conditions. A recency effect was more marked for Experiment 2 than for Experiment 1, suggesting that short-term storage of unrehearsed digits is more effective in auditory than visual modality, but there was little evidence within modalities to support decay theory.

68. Corballis, M. C. Memory span as a function of variable presentation speeds and stimulus durations. Journal of Experimental Psychology, 1966, 71, 461-465.

Digit-span series were presented on 3 films, 1 to each of 3 groups 20 Ss. In Film 1, presentation speed was varied between series. In Film 2, it was varied within series as well. In Film 3, it was varied between series only, but degree of variability between series was more extreme than in Films 1 or 2. Stimulus duration was varied in all 3 films. When stimulus durations were long, number correct was higher the slower the presentation speed, but when stimulus durations were short, there was a tendency for this trend to be reversed in Films 1 and 2, though not

in Film 3. Implications of these findings are discussed.

69. Corballis, M. C. Immediate recall of spoken digits presented three at a time. Canadian Journal of Psychology, 1967, 21, 416-424.

Spoken digits were presented via three "channels," created by presenting the digits through earphones three at a time, one to each ear and a third to both ears at once. If Ss received two such triplets in succession at a slow presentation rate (one triplet every 2 sec.), they usually attempted to report the digits in the first triplet followed by those in the second, a "temporal" mode of report. But when presentation was fast (one triplet every sec.), the incidence of temporal report decreased and over-all accuracy of recall declined. "Channel by channel" report, though often attempted when presentation was fast, was not an efficient recall strategy.

70. Corballis, M. C. & Loveless, T. The effect of input modality on short-term recall. Psychonomic Science, 1967, 7 (8), 275-276.

Immediate recall of eight visually presented items was better if the first four were presented fast and the last four slowly (FS Condition) than if the first four were slow and the last four fast (SF Condition), supporting an hypothesis that Ss tend to rehearse cumulatively. Using aural presentation, Schonfield & Donaldson (1966) have obtained the opposite result, supporting decay theory. These and other results suggest that rehearsal of serially presented information is more efficient and flexible when presentation is visual than when it is aural.

71. Corballis, M. C. & Sampson, H. Scanning and immediate memory in serial adding. Australian Journal of Psychology, 1963, 15, 99-107.

Performance on a paced serial addition task (PSAT) under variable pacing and stimulus duration conditions was compared with that on two related tasks, whose basic operations were respectively integration (in this instance, adding) and immediate memory, each a component operation of the PSAT. Results showed that none of the PSAT performance trends appeared on the first of these related tasks, but all were significant on the second. These support a hypothesis (Sampson, 1958) that the stimulus duration effect reflects an immediate memory disturbance, and show that the integration component can account for none of the trends. Consideration of the nature of the pacing effect suggested that a central scanning operation may also be important.

72. Corcoran, D. W. J. Recognition of complex sounds over the long and short term. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 380-385.

A population of eight stimuli was synthesized by dichotomizing three parameters, pitch (a) interruption rate (b) and amplitude modulation of the interruption (c). A single "Target" stimulus (a + b + c +) had to be recognized after training under five different procedures. Group T had 32 presentations of a + b + c +; C-, 16 a + b + c + and 16 a + b + c -; A-, 16 a + b + c + and 16 a - b + c +; A-B-C- had 16 a + b + c presentations with 16 a - b - c -, and 1 had 16 a + b + c + with a verbal descrip-

tion of the parameters. Tests of recognition were conducted after 1 min and 10 days. Three theories were matched against the data. The most adequate theory for the short-term results was not the best explanation of long-term retention and vice versa.

73. Corcoran, D. W. J. & Weening, D. L. Redundancy effects in short-term memory. The Quarterly Journal of Experimental Psychology, 1967, 19, 309-318.

Five experiments are reported whose purpose was to demonstrate that short-term memory is improved by redundancy within the material. In Experiment I "tunes" containing two, three, four and five tones of differing frequencies had to be coded into digits 1-5, to indicate the order of the pitches in a tune. Performance on stimuli containing correlated amplitude and duration were compared with the unidimensional condition. Experiment II repeated I, but required intensity to be coded. Experiment III required pitch coding under three conditions including that when amplitude and frequency were uncorrelated, and compared the performance of musically trained subjects with nonmusicians. Experiment IV repeated III, but subjects were informed of the relation between dimensions. Experiment V involved "shadowing" the tunes by whistling simultaneously with the stimulus.

It was concluded (a) that intercorrelation improves, but zero correlation impairs short-term memory; (b) that knowledge of the relation between dimensions improves performance in the correlated condition, but does not prevent impairment under zero correlation; and (c) the performance of musically trained subjects exceeds that of controls and is unaffected by the presence of a correlated or uncorrelated dimension.

74. Corman, C. D., Bostic, W. D. & Wickens, D. D. The effect of the position of stimulus cueing on short-term memory. Psychonomic Science, 1966, 6, 305-306.

Ss were presented with two potential items on each of a series of STM trials. On some trials, Ss knew which item was to be recalled before item presentation; on other trials, they did not. Although the procedure precluded rehearsal, prior knowledge of which item was to be recalled facilitated that recall. Ss' reports indicated this knowledge was utilized through the association of the to-be-remembered item with an "encoder."

75. Crannell, C. W. Code learning and color. Journal of Psychology, 1964, 58, 295-299.

Upon exposure of associated pictures of the decorative sticker variety, four groups of college students learned to produce letters of the alphabet or numerals or simple words. Two methods of learning (whole and part) and two types of pictures (in full color and in black-and-white) were assigned at random to Ss so as to make up the four groups. Neither method nor code type was found to affect the number of trials taken in original learning nor the amount of recall after three weeks without intervening practice. The materials tended to be unusually easy to learn and to re-

tain, and it is suggested that when this is true little is to be gained by the use of color in the stimulus pattern.

76. Crannell, C. W. & Parrish, J. M. A comparison of immediate memory span for digits, letters, and words. Journal of Psychology, 1957, 44, 319-327.

The immediate memory span was tested for 24 college students with three types of materials: digits, letters, and real words. The letters and words were subdivided into two types: limited lists containing only nine different items and lists containing any of the 26 letters or entirely different three-letter words. The lists were presented on a tape recorder and reproduced orally by Ss. The shortest lists contained four items of the specified type, and the longest 12 items. For any S testing with any material ceased when four consecutive lists were failed.

The immediate memory span was found to be significantly longer for digits than for letters or words, and the span for letters was found to be significantly longer than that for words. The effect of limiting the letter or word lists to a pool of nine different items was found to be negligible. The results lead to the conclusion that the number of different stimuli with which S must contend is not a critical factor. The differences among habits or past experiences with digits, letters, and words appear to be crucial, but these differences are probably more a matter of the associative trends fostered by the materials, rather than a matter of frequency alone.

77. Crawford, J., Hunt, E., & Peak, G. Inverse forgetting in short-term memory. Journal of Experimental Psychology, 1966, 72, 415-422.

As a test of short-term memory, human Ss were shown a pattern of letters, then asked to recall it. Stimuli were presented for less than 1 sec., while the retention interval varied from 1 to 10 sec. The letter patterns used were either meaningless, formed words, or formed sentences. There was no intervening activity during the retention interval. Accuracy of recall was higher at longer retention intervals, in contrast to the usual fall of accuracy with time which is seen when retention is measured over a period of minutes or longer. Degree of meaningfulness of the stimuli did affect accuracy of recall, but there was no interaction with the retention-interval effect.

78. Crovitz, H. F. & Schiffman, H. R. Visual field and the letter span. Journal of Experimental Psychology, 1965, 70, 218-223.

Three experiments tested the relations between monocular or binocular viewing, visual-field placement of stimuli, and interletter spacing in the distribution of errors over letter positions in the letter span. Exposure time was 100 msec. The most important variable in accuracy within the letter span was found to be the relative location of a letter within the 8-letter line. Errors were fewest for the leftmost letter in the line regardless of variations in absolute retinal locus. These data imply that experiments on the letter span might better be conceptualized as "memory" studies than as "perception" studies.

79. Crowder, R. G. Visual presentation of stimuli in immediate memory. Psychonomic Science, 1966, 6 (10), 449-450.

Stimultaneous (SM) and sequential (SQ) visual presentation of consonant series varying in length were compared as a function of stimulus duration and presentation rate, respectively. A systematic dependence of recall upon these parameters was demonstrated for two measures of performance. Second for second, SM presentation was found to be more efficient than SQ.

80. Crowder, R. G. Reciprocity of retention and interpolated-task scores in short-term memory. Perceptual and Motor Skills, 1967, 24, 903-909.

A serial reaction task was used as the interpolated activity in an experiment testing short-term memory (STM) for word strings after 30 sec. Significant effects of the complexity of each task upon performance of the other were found, viz., retention of five-word stimuli led to poorer performance on an interpolated task than retention of three-word stimuli, and a stimulus-response lag in the reaction task reduced memory scores. However, there was not clear evidence for reciprocity of performance levels from trial to trial within Ss. The recognition that STM experiments employ divided-attention paradigms is potentially important in the interpretation of proactive inhibition effects.

81. Crowder, R. G. Short-term memory for words with a perceptual-motor interpolated activity. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 753-761.

It was maintained that the Brown-Peterson short-term memory (STM) task bears important similarities to procedures used in the study of division of attention, since during STM retention intervals there is competition between the tendencies to rehearse the memory item and to execute the filler activity. It follows that when both retention and filler-task performance are scored, either or both should be sensitive to variables known to affect the division of attention, such as task-complexity and practice. In two experiments recall for 5-word stimuli was tested after 24-sec intervals filled with a self-paced keypressing task as the interpolated activity. Evidence for the presence of rehearsal was the finding that keypressing scores were lower on memory trials than on control trials where no words were recalled. Furthermore, retention scores were found to be a complex joint function of the S-R compatibility, coherence (repetitiveness), and prior practice on the keypressing activity. The conclusions were that rehearsal is objectively demonstrable in STM, that its extent may be controlled by variation of the filler task, and that the relationships revealed by such variation are consistent with the experimental literature on divided attention.

82. Crowder, G. & Melton, W. The Ranschburg Phenomenon: Failures of immediate recall correlated with repetition of elements within a stimulus. Psychonomic Science, 1965, 2, 295-296.

Seven-consonant stimuli were recalled immediately. When the consonant in Position 2 was repeated in Position 5, 6, or 7, an increase in errors occurred at the latter position, as compared with control stimuli involving no repetition. Confirmation of the Ranschburg Phenomenon does not occur, however, when the repeated-element positions are 2 and 4. Nor was there an increased error rate for elements following a repeated element. These observations support the importance of intra-stimulus interference in immediate memory, but leave uncertain the associative mechanism responsible for such interference.

D

83. Dainoff, M. & Haber, R. N. How much help do repeated presentations give to recognition processes? Perception and Psychophysics, 1967, 2, 131-136.

A recent experiment by Haber and Hershenson (1965) had shown that in a recognition task one long look at a stimulus was always superior to two or more shorter looks summing to the same total presentation time. In order to explore this more fully and to account for opposite results in a different type of recognition task, as well as in a serial learning task, an improved replication of the earlier study was carried out using very short durations and single letters as stimuli. The same non-reciprocity was found, again strongly favoring duration over repetition as a determinant of clarity of a percept, even though repetition alone was also shown to be a significant independent variable. As a subsidiary finding, an error analysis showed that when a letter was misnamed it was nearly always confused with one that looked like it rather than one that sounded like it. Some discussion was offered as to the role of an auditory information storage in low memory load tasks such as this one, as well as some general implications for information processing analyses of the non-reciprocity of duration and repetition.

84. Dale, H. C. A. When recognition is no better than recall. Nature, 1966, 211, 324.
85. Dale, H. C. A. Response availability and short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 47-48.

Response availability within a single category was assessed by asking Ss to enumerate the complete category. Ten stimuli were then picked at roughly equal steps along the availability scale. These were used in an immediate free-recall experiment with new Ss. Recall was found to be correlated with availability, the most readily available items being recalled best.

86. Dale, H. C. A. & Gregory, M. Evidence of semantic coding in short-term memory. Psychonomic Science, 1966, 5, 75-76.

An effect of semantic similarity in short-term memory was demonstrated and was compared with the effect of acoustic similarity. In recall, using the RI paradigm, semantic similarity between OL and IL increased intrusions from IL, but decreased omissions. By contrast, acoustic similarity caused both IL - intrusions and omissions to increase.

87. Dallett, K. M. Effects of a redundant prefix on immediate recall. Journal of Experimental Psychology, 1964, 67, 296-298.

Ss were presented with strings of 7 or 8 digits immediate recall. 5 conditions were compared: 7 random digits, 8 random digits, 7 digits to which S was required to add a redundant 0 prefix in recall, 8 digits including a redundant 0 prefix, and 8 digits including a redundant prefix which S was required to omit in recall. The prefix was redundant in the sense that S was advised in advance of its presence and advised that it would appear with 10 successive digit strings. Recall of 7 random digits was superior to all other conditions, which did not differ among themselves.

88. Dallett, K. M. Intelligibility and short-term memory in the repetition of digit strings. Journal of Speech and Hearing Research, 1964, 7, 362-368.

Twenty-eight normal subjects heard seven digits masked by noise, and repeated either (a) the first three digits, (b) the last three digits, (c) all seven digits, or (d) all seven digits after saying "zero." Over the range of intelligibility tested (approximately 60% to 100%), accuracy of seven-digit repetition improves linearly as accuracy of three-digit repetition improves, with the average slope being near 1.00. These data were interpreted to mean that the decrement in intelligibility that results from masking is accompanied by an added decrement in short-term memory.

89. Dallett, K. M. "Primary memory": The effects of redundancy upon digit repetition. Psychonomic Science, 1965, 3, 237-238.

Ss tried to repeat series of 8 digits immediately after hearing them. Each series of digits had a predictable digit (a zero) in a known location, and Ss were told to omit this digit. Performance in this task is similar to the performance obtained in repetition of 8 non-redundant digits, although if the redundant element is near the center of the series, Ss can improve their recall of the other digits. Digit recall seems to be largely, but not entirely, a matter of "primary memory," which involves a more or less faithful unrecoded replica of stimulus input.

90. Dalrymple-Alford, E. C. Repetition and immediate memory. The British Journal of Psychology, 1967, 58, 63-67.

Subjects were presented with digit-combinations one digit at a time, in such a manner that each succeeding digit was presented only after all the preceding digits had been repeated by the subject in correct order. The number of digits the subjects could 'carry' in general did not differ from their memory spans. This together with the distribution of serial positions at which repetition broke down is taken as evidence for the view that repetition restores but does not further strengthen memory traces.

91. Davis, R., Sutherland, N. S. & Judd, B. R. Information content in recognition and recall. Journal of Experimental Psychology, 1961, 61, 422-429.

In previous experiments on recognition and recall, there has been no clear limit to the number of alternatives from which Ss were selecting in recall: the superiority of recall over recognition normally found may be due to selection being made from a larger ensemble in recall than in recognition. The present experiment was designed to test the hypothesis that the amount of information conveyed in recognition is the same as that in recall. The Ss were given one presentation of lists of 15 two-digit numbers and 15 two-letter syllables and then asked to recall or recognize symbols from the list presented. Each S served in four conditions: recognition out of a list of 30, recognition out of 60, recognition out of 90, and recall from an ensemble of 90. Performance scores were transformed into a measure of the amount of information transmitted per S under each condition. It was found that at least as much information was transmitted in recall as in recognition and that the amount of information transmitted in the recognition condition tended to increase as the number of alternatives from which selection was made increased.

92. Deese, J. Influence of inter-item associative strength upon free recall. Psychological Reports, 1959, 5, 305, 312.

Lists consisting of 15 words each were presented to Ss for immediate free recall. For each of the 18 lists a measure of inter-item associative strength was obtained; this consisted of the average relative frequency with which all items in a list tend to elicit all other items on the list as free associates. Inter-item associative strength was positively correlated (.88) with the number of words recalled per list, negatively correlated (-.48) with the number of extra-list intrusions in recall, and positively correlated (.55) with the commonality of the extra-list intrusions that did occur. In general, these results are consistent with an interpretation of free recall in terms of free association. Free association, as it occurs in recall, is probably a direct, unmediated activity with little or no active editing of the material being recalled. The data on intrusions from the present experiment are consistent with the assumption of lack of editing. The fact that Ss in the present experiment gave no evidence of using an extra-list associative mnemonic device made available to them suggests that the free association from item to item in recall is not the result of Ss' instructing themselves to free associate in order to increase recall.

93. Deese, J. Frequency of usage and number of words in free recall: The role of association. Psychological Reports, 1960, 7, 337-344.

The present experiment reports data on number of words correctly recalled after one presentation of lists varying in (a) frequency of usage of the words in the lists and (b) number of words presented for recall in any given list. The mean number of words recalled increases both with frequency of usage and list length; there is also an interaction between frequency and list length such that recall for high frequency long lists is disproportionately higher than for low frequency long lists. The words used in the present experiment were chosen at random, with only the restrictions

of frequency of usage and list length. Nevertheless, it was discovered that certain of the lists contained words associatively related to one another. An index of the average tendency for all words in each list to be elicited as associates by all other words in that list was computed. This index of inter-word association was larger with randomly selected high frequency lists than with low frequency lists and with longer than with shorter lists. Evidence was produced which tended to support the hypotheses that variation in free recall scores with frequency was largely the result of differences between frequencies in inter-word associations, and that the interaction between list length and frequency on free recall was likewise largely the effect of inter-word association.

94. Deese, J. & Kaufman, R. A. Serial effects in recall of unorganized and sequentially organized verbal material. Journal of Experimental Psychology, 1957, 54, 180-187.

The results of two experiments on the immediate recall of verbal material are presented. For lists of words in which there is no sequential association between adjacent words (randomly arranged lists), Ss recall the individual items in order of their probability of being recalled. For these kinds of lists, the last items are recalled most frequently, the first items next most frequently, and the middle items least frequently. For passages of connected discourse, the order of recall is in the order with which the material is presented, and the serial position curve of frequency of recall is like that obtained by the method of serial anticipation with nonsense material (and roughly the mirror image of that obtained with free recall of nonsense material). It is probably that the serial position curve obtained with textual material depends upon the serial order of emission during recall. It was demonstrated by the use of the orders of approximation to textual English devised by Miller and Selfridge (3) that increasing the sequential dependency from zero to that characteristic of textual English changes the order and frequency of recall from those characteristic of free recall of disconnected material to those characteristic of serial anticipation. Thus, recall of sequentially dependent material involves more than the organization of words into larger groups, it also involves the reorganization of the patterns of emission of responses and changing the relative frequency with which items in various positions are recalled.

95. Derks, P. L. & Freeman, L. Recall of simultaneously and successively presented information. Psychonomic Science, 1966, 5 (2), 51-52.

In order to examine the reported similarity in error distribution for recall of successively and simultaneously presented material, the two conditions were compared under total and partial report procedures. However, in this study, omission errors were predominately at the front of the list for successive presentation and to the right for simultaneous presentation with both report procedures. Further investigation of successive presentation total report showed mislocation errors shifted toward the rear of the list relative to omission errors. These results lend some support to descriptions of memory which include a "reception" stage and an "organization" stage. The similarity in error distributions for successive and simultaneous presentations results in part from similar organizational strategies.

96. Donaldson, W. & Murdock, B. B., Jr. Criterion change in continuous recognition memory. Journal of Experimental Psychology, 1968, 76, 325-330.

Signal-detection analysis was applied to a continuous short-term recognition memory task for 3-digit numbers. The typical increasing false-positive rate accompanying progress through the task was indicated to be due solely to a shifting criterion and not to a buildup in proactive interference. This suggests that, in terms of memory capacity, a "steady state" has been obtained.

97. Dornbusch, R. L. & Winnick, W. A. Short-term intentional and incidental learning. Journal of Experimental Psychology, 1967, 73(4), 608-611.

Short-term intentional and incidental learning were studied as a function of instructions, rate of presentation, and type of retention test. There were 2 levels of instructions (intentional, incidental), 2 rates of presentation (.25 sec. and 4 sec.), and 2 tests of retention (recall, recognition). Intentional scores were found to be significantly better than incidental only for the recall test following 4-sec. presentation, while incidental scores were significantly superior on the recognition test following the .25-sec. rate. The data indicate that an essential difference between intentional and incidental Ss is in the use of additional representational responses by the intentional group.

E

98. Ellis, N. R. & Anders, T. R. Effects of postresponse stimulus duration upon short-term memory. Journal of Experimental Psychology, 1967, 75(3), 418-424.

3 experiments assessed the effects of postresponse stimulus duration in a 2-choice concurrent short-term memory task. Ss, college students, responded to 1 of a pair of stimuli (geometric designs) on a training trial and after varying numbers (0, 1, 2, 3, 4) of intervening trials (which were also training or test trials) received a test trial. In a 1st study, Ss received PSDs of 0, 1, 2, and 3 sec. A 2nd, varied PSD (0, 1.5, and 3 sec.) and intertrial interval (0, 3, 6, and 9 sec.), and a 3rd, contrasted a correction and noncorrection procedure with a 0-sec. PSD. PSD, ITI, and number of interpolated items substantially affected performance with each of the PSD and ITI groups separating reliably. Performance decayed systematically with increased number of interpolated items. No significant interaction obtained between PSD and ITI. The correction and noncorrection groups did not differ significantly.

99. Eriksen, C. W. Temporal luminance summation effects in backward and forward masking. Perception and Psychophysics, 1966, 1, 87-92.

Two experiments tested six predictions derived from the assumptions underlying the luminance summation-contrast reduction explanation for certain instances of forward and backward masking effects. The predictions concerned the circumstances under which masking would occur and also that forward masking would be more extensive than backward masking under specified luminance arrangements. All six predictions were confirmed.

100. Eriksen, C. W. & Collins, J. F. Reinterpretation of one form of backward and forward masking in visual perception. Journal of Experimental Psychology, 1965, 70, 343-351.

2 experiments were performed on the masking effect of a ring stimulus upon forced-choice recognition of letter forms when the ring was presented concurrently with the form or preceding or following the form at delay intervals up to 250 msec. 10 Ss were employed in Experiment I (backward masking) and 10 in Experiment II (forward masking). Masking effects on recognition accuracy were obtained for delay intervals as long as 80 msec. Maximum masking occurred when ring and form occurred concurrently. The masking functions obtained for forward and backward masking appeared highly similar if not identical. An interpretation was suggested in terms of visual perceptual persistence where masking is due to the greater difficulty of perceiving a form surrounded by a black ring. Possible perceptual mechanisms for the persistence were considered.

101. Eriksen, C. W. & Hoffman, M. Form recognition at brief durations as a function of adapting field and interval between stimulations. Journal of Experimental Psychology, 1963, 66, 485-499.

2 experiments explored the questions as to whether an unrecognized stimulation has an effect upon the recognition of a subsequent stimulation and the duration of the time interval between successive presentations of a weak stimulus in order for the recognitions of the stimulus to be independent of one another. By means of a 3-field tachistoscope the recognition for a form presented twice where the interval between presentations was 0, 5, 250, or 450 msec. was compared with recognition for a single exposure of the form at the same duration. 4 conditions involving variation of the brightness of adapting field and of the interval between form presentations were investigated. In Experiment I, 5 practiced Ss made judgments under all conditions. In Experiment II, 12 Ss were assigned, 3 to each condition. Recognizability was found to be a complex function of whether a form was followed or preceded by a flash of light, the lag time between stimulations and the brightness of the adapting field. The results were explained in terms of brightness summation that resulted in reduced figure-ground contrast for the form. Double presentation was slightly superior to single presentations, the amount of gain being a negatively accelerated function of lag time between the 2 presentations.

102. Eriksen, C. W. & Johnson, H. J. Storage and decay characteristics of non-attended auditory stimuli. Journal of Experimental Psychology, 1964, 68, 28-36.

4 Ss were individually run through 20 2-hr. sessions during which their primary task was to read a novel of their own choosing. At random intervals during the session a 1,000-cycle, 1/2-sec. tone of low intensity occurred. At delays ranging from 0 to 10.5 sec. following onset of the tone an alerting stimulus (reading lamp turned off) occurred. At the alerting stimulus S had been instructed to interrupt his reading and make a judgment as to whether the tone had occurred during the immediately preceding 10-15 sec. period. Sessions were run under a high and low condition of irrelevant noise. Detection of the signal was found to be a decay function of the delay of the alerting stimulus out to delays of 10.5 sec. 4 Ss were run in a 2nd experiment to determine whether the detection at 10.5 sec. delay represented the spontaneous rate for detection without an alerting stimulus. Significant memory at 10.5 sec. delay over the spontaneous detection rate was found. No effect of level of extraneous background noise was found. Implications for models of attention were considered.

103. Eriksen, C. W. & Lappin, J. S. Selective attention and very short-term recognition memory for nonsense forms. Journal of Experimental Psychology, 1967, 73(3), 358-364.

In 2 experiments Ss received displays containing 2 or 4 nonsense forms presented for 125 msec. and followed by a single test form at delays of 0-1,000 msec. S judged whether the test form was or was not included among the forms in the display. 4 form displays were presented under 2 conditions, 1 where directional bar markers directed Ss to the top or bottom pair of forms and another condition where no indicators were present. In the latter condition an indicator occurring at the time of the test form directed S to make his decision on the basis of the top or bottom pair of preceding display forms. Recognition was superior at all delay intervals for 2-form displays, and 4-form displays with the simultaneous indicator were superior to 4-form displays where the indicator was delayed until the test form. The results were interpreted in terms of a selective process in visual attention and a masking effect apparent in the data was interpreted in terms of saccadic eye movement.

104. Eriksen, C. W. & Steffy, R. A. Short-term memory and retroactive interference in visual perception. Journal of Experimental Psychology, 1964, 68, 423-434.

3 experiments were performed on the relation of backward masking effects in visual perception and short-term perceptual memory. In all experiments the first stimulus was a brief presentation of a display consisting of a random pattern of Xs and Os arranged in a circular pattern. At predetermined intervals after termination of the display (10-700 msec.) an arrow appeared indicating a position on the preceding display and S reported whether the position had contained an X or O. In none of the experiments was any evidence found of a brief perceptual memory. Experiment I showed impaired performance when indicator followed display within 100 msec. In Experiment II elimination of possibility of luminance summation resulted in no significant effect attributable to delay of the indicator. Experiment II indicated marked individual differences in retroactive interference functions occasioned by the delay of the indicator.

105. Erlick, D. E. Judgments of the relative frequency of a sequential series of two events. Journal of Experimental Psychology, 1961, 62, 105-112.

The effects of sequence, duration of observation, and rate of occurrence on the perception of the more frequently occurring event of a sequential series of two mutually exclusive events was investigated. It was found that: when both events are equally frequent, the event having the higher degree of clustering is estimated as having a higher relative frequency of occurrence; the relative degree of cluster - not the absolute magnitude of the cluster - appears to influence the perception of relative frequency; as duration of observation increases from very short time periods, the 75% threshold of identifying the more frequent event decreases and then increases; as rate of presentation increases, this threshold decreases; rate interacts as a

function of duration of observation; i.e., the shorter the duration, the steeper the decline in accuracy as a function of increasing rate; and an increment (ΔF) of approximately 10 to 20% of the more frequent event (E_M) is required to maintain 75% accurate identification of E_M with observation times beyond 5 sec. and rates of presentation 8 per sec. or slower. The results are explained in terms of the discrimination of varying size clusters of events or "chunks" of the sequence of events.

106. Erlick, D. E. The ability to filter noise from a visual task when the noise and signal are presented sequentially. Journal of Experimental Psychology, 1962, 63, 111-114.

The ability of human Ss to filter out noise from a task when the signal and noise are presented sequentially was investigated. Two levels of signal intensity and five signal-to-noise ratios (ranging from 1 to 22) plus a no-noise condition were used. A condition using blank time intervals instead of noise at all signal-to-noise ratios was also used. The task involved the judgment of the relative frequency of two random sequential categories (letters A and B presented visually). Ten different letters randomly interspersed among As and Bs represented the noise. There were no significant differences among any of the foregoing conditions, indicating that Ss effectively filtered out the noise when it was presented in sequential relationship to the signal.

107. Erlick, D. E. Perception of the most frequent category of a random series as a function of the number of categories. Journal of Experimental Psychology, 1962, 63, 115-118.

The ability to perceive the more frequently occurring category in a random series as a function of the number of different categories was investigated. The main variables of concern were: the relationship between information transmitted (T) and (a) the frequency difference between categories (ΔF), and (b) the information input (H). The different categories were 2, 4, 8, or 12 (H in bits = 1, 2, 3, and 3.6, respectively). Within each H condition a basic frequency of 20 was used for all except one category, which had an increased frequency of one of five values. Categories were presented randomly at the rate of four per sec. The Ss were instructed to indicate the category which appeared most frequently. The results indicate that approximately the same linear relationship exists between T and ΔF for all H conditions with $T = .0113 \Delta F - .1342$. The relationship between T and H indicates a slight decrease in T as H increases.

108. Erlick, D. E. Effects of grouping of stimuli on the perception of relative frequency. Journal of Experimental Psychology, 1963, 66, 314-316.

The ability to perceive the overall relative frequency of 2 groups of random sequential categories as a function of the number of categories per group was investigated. The number of categories per group was the same for the 2 groups being compared, i. e., either 1 (C_1), 2 (C_2), or 4 (C_4). Letter sequences were used to represent categories within a group. The S's task was to determine whether the combined total frequency of A or C was greater (C_1); or D + E or G + H was greater (C_2); or Q + R + S + T or W + X + Y + Z was greater (C_4). All the letters comprising both groups being compared were presented in a random sequence 1 at a time at the rate of 4 per sec. The results indicate an approximately linear function between the information transmitted (T) and the frequency difference between the groups of categories (ΔF) for each of the 3 C conditions. The slope $T/\Delta F$ decreased in a linear fashion as a function of C; slope $T \Delta F = .0020 C + .0133$.

109. Ehrlich, N. J. Hypnotic control of interpolated activity in a short-term memory task. Psychonomic Science, 1964, 1, 167-168.

Hypnotic control may be used as a means of specifying the exact nature of the interpolated interval in short-term memory, allowing for investigation of such items as time of rehearsal, amount of rehearsal and the like in a direct fashion. Conclusions for this demonstrative paper are limited to (a) a strong indication that level of nonspecific emotion is unrelated to memorial capacities and (b) while presence or absence of rehearsal is the dominant factor in determining performance in memory tasks, such variables as stimulus-rehearsal interval bear exploration.

110. Estes, W. K. Information storage in behavior. In: Proceedings of the International Union of Physiological Sciences, Vol. III. Information Processing in The Nervous System, 1962, 280-287.

111. Estes, W. K. & Taylor, H. A. Visual detection in relation to display size and redundancy of critical elements. Perception and Psychophysics, 1966, 1, 9-16.

Visual detection was studied in relation to displays of discrete elements, randomly selected consonant letters, distributed in random subsets of cells of a matrix, the S being required on each trial to indicate only which member of a predesignated pair of critical elements was present in a given display. Experimental variables were number of elements per display and number of redundant critical elements per display. Estimates of the number of elements effectively processed by a S during a 50 ms. exposure increased with display size, but not in the manner that would be expected if the S sampled a fixed proportion of the elements present in a display of given area. Test-retest data indicated substantial correlations over long intervals of time in the particular elements sampled by a S from a particular display. Efficiencies of detection with redundant critical elements were very close to those expected on the hypothesis of constant sample size over trials for any given display size and were relatively invariant with respect to distance between critical elements.

112. Eysenck, H. J. A three-factor theory of reminiscence. British Journal of Psychology, 1965, 56, 163-181.

A three-factor theory of reminiscence is suggested, making use of the concepts of consolidation, reactive inhibition and conditioned inhibition. It is further suggested that the reminiscence phenomenon is highly task-specific, in the sense that different tasks call differentially for the various processes hypothesized. Furthermore, it is suggested that differences in drive conditions, personality, fatigue, drug administration and many other variables impose definite limits to the replication of research findings, and that only specific studies of the influence of these variables, within a given theoretical context, can lead to a proper quantitative theory of reminiscence.

F

113. Fraser, D. C. Decay of immediate memory with age. Nature, 1958, 182, 1163

Two groups of twenty-six teachers served as subjects in the present experiment designed to replicate the previous findings by Conrad. These findings indicate that fast presentations are recalled better than slow presentations.

Groups A and B consisted of those individuals in the age ranges of 18 to 29 and 30 to 55 respectively. All subjects were presented eight-digit numbers at rates of 120 digits per minute and 40 digits per minute.

The results confirm those previously reported by Conrad in that recall was in fact better for the fast condition. The span of immediate memory, demonstrated by the fast condition, was found to be the same for each group. However, the rate of decay of immediate memory, demonstrated by the slow condition, was shown to increase with age. (DFF)

G

114. Gibson, J. J. The problem of temporal order in stimulation and perception. Journal of Psychology, 1966, 62, 141-149.

The concept of memory in its relation to perception is a muddle. If we accept the fact of sequential perception, rejecting the fiction of momentary pattern-perception, matters become more intelligible. If perception involves the apprehension of a changing world, not a frozen one, the problem is that of detecting invariants under transformation. The permanence can be isolated just because the perspectives change. The latter do not have to be stored up and put together in a composite. The mechanism of perceptual learning is one in which the nervous system resonates to the invariants of the stimulus flow, as Lashley suspected, not one of storage and retrieval of engrams. The recalling of the past, the capacity (in some persons) to summon memory images into consciousness, may well be a quite incidental accompaniment of learning, not its basis.

115. Glanzer, M. Accuracy of perceptual recall: An analysis of organization. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 289-299.

A series of investigations was carried out to analyze the determinants of the difficulty of perceptual recall of a systematically varied set of stimuli. The stimuli were arrays of eight shapes that were each either black or white. In Part I, the accuracy with which Ss could reproduce these arrays under .5-sec. exposure was determined. In Part II, another method involving discrimination between arrays yielded a similar ranking of accuracy scores. This indicated that the scores obtained in Part I were not a function of the particular method used. The accuracy scores of Part I were then subjected to various types of analysis. An analysis based on information measure showed some success in accounting for the difficulty of individual arrays. For several reasons this analysis was found to be unsatisfactory. Another type of analysis was constructed, based on the verbal-loop hypothesis--the hypothesis that the Ss' perceptual processing includes a covert verbalization and that the length of the verbalization determines the difficulty of the stimulus for perceptual tasks. Empirically derived measures based on this hypothesis were shown to account for a major part of the variance in array difficulty. The relevance of the assumption and the findings to the general problem of perceptual organization and encoding is discussed. The verbal-loop hypothesis is presented as an alternative to gestalt and information theory analyses of organization.

116. Glucksberg, S. & Balagura, S. Incremental memory: availability and encoding of stimulus items. Presented at Psychonomic Society, 1965.

Repetition effects in a brief visual memory task varied as a function of amount of material encoded. In contrast, varying the amount of material available in short-term store had no effect. The results support Hebb's assumption concerning the operation of temporary activity traces in very short-term memory.

117. Glucksberg, S., Fisher, D. F. & Monty, R. A. Brief visual memory as a function of visual and acoustic confusability. Proceedings of the 75th Annual Convention, American Psychological Association, 1967, 55-56.
118. Glucksberg, S., Karsh, R., & Monty, R. A. Sequential memory: Keeping track performance as a function of information exposure time and interstimulus noise. Perceptual and Motor Skills, 1967, 24, 651-656.

Ss were required to keep track of the number of occurrences of each of three pure tones presented at a constant rate in sequences (trials) of various lengths. With trial lengths of 8 and 12 tones, as practice progressed the shorter the stimulus exposure duration, the better the performance. This effect was not obtained with trial lengths of 16 and 20 tones. White noise presented during interstimulus intervals did not affect performance. Implications for a model of keeping-track behavior are examined.

119. Glucksberg, S. & Laughery, K. R. Sequential memory as a function of total time of information exposure and availability of information-processing strategies. Proceeding of the American Psychological Association, 1965, 79-80.
120. Gomulicki, B. R. The development and present status of the trace theory of memory. British Journal of Psychology (Monograph Supplement), No. 29
121. Gorman, A. M. Recognition memory for nouns as a function of abstractness and frequency. Journal of Experimental Psychology, 1961, 61, 23-29.

An operational definition of abstractness in nouns was constructed by using the human discriminative response to identify two points on a scale of abstractness. This scale, consisting of 490 "abstract" and 571 "concrete" nouns, was found to have adequate reliability. When the scale was manipulated as an independent variable, the effect of abstractness of short-term recognition memory was highly significant, "abstract" nouns being less well remembered than "concrete" nouns. Frequency was found to be a pertinent variable, independent of abstractness, very frequent nouns being less well remembered than somewhat rarer nouns.

122. Green, D. M. & Moses, F. L. On the equivalence of two recognition measures of short-term memory. Psychological Bulletin, 1966, 66, 228-234.

Two tests of short-term, recognition memory were compared. An extension of signal-detection theory was used to generate prediction from 1 test to the results of the other. These predictions were investigated for an individual S's memory of about 100 nonsense syllables. The errors in predictions were about what might be expected assuming binomial variability in the 2 measures.

H

123. Haber, R. N. A replication of selective attention and coding in visual perception. Journal of Experimental Psychology, 1964, 67, 402-404.

The replication supported and extended the findings of an experiments by Harris and Haber (1963). The form of Ss' verbal encodings of briefly presented stimuli was found to account for the effects of attention instructions on accuracy of their reports. Attention instructions had a smaller effect on Ss who encoded the stimulus in the order dictated by English syntax. The Ss who encoded first the stimulus attribute they were told to attend to, reported this attribute more accurately.

124. Haber, R. N. Effects of coding strategy on perceptual memory. Journal of Experimental Psychology, 1964, 68, 357-362.

Thirty-seven Ss were taught 1 of 2 strategies to encode and rehearse orally briefly presented multidimensional stimuli. Analyses were directed at separating the effects on accuracy of encoding processes and of retention processes. Regarding the former, the 2 strategies differed on the speed of encoding and on the accuracy of encoding. Further, stimuli encoded slowly were more likely to contain errors, independent of retention processes. Regarding these latter processes, the strategies differed on several types of interference responses during rehearsal (retention), responses that produced errors during rehearsal, independent of errors made during encoding. These results supported hypotheses about speed of encoding, and interference during retention, and showed how these effects could account for differences between the coding strategies.

125. Haber, R. N. The nature of the effect of set on perception. Psychological Review, 1966, 73, 335-351.

To explain the effects of set on reports of perceptual experience 2 hypotheses are elaborated--set enhances the percept directly, or set facilitates responses and memorial organization of the perceptual experience that itself was unaffected by the set. Extensive research is reviewed that is relevant to each of these hypotheses, especially studies that attempt to differentiate them.

126. Haber, R. N. & Hershenson, M. Effects of repeated brief exposures on the growth of a percept. Journal of Experimental Psychology, 1965, 69, 40-46.

Exposure duration and the number of times the word was flashed (trials) were varied independently in order to investigate the growth of the perception of a word. With duration constant, the probability of perceiving a word increased with exposure trials so that the word was quite clear and easily identified after a number of flashes, even if the first flash appeared blank. The function relating the probability of perceiving a word to the number of exposure trials could be specified knowing only the asymptote (maximum probability attainable) and the probability of perceiving the

word on the first exposure. Despite this effect of repeated exposures, the probability of perceiving a word was always higher for a single flash at a given duration than for 2 or more flashes at shorter duration summing to the same total duration.

127. Hanawalt, N. G. & Diepenbrock, E. C. Verbal context and meaning in immediate and delayed recall. Journal of General Psychology, 1965, 73, 125-135.

Two experiments were performed to test Miller and Selfridge's hypothesis that short-range associations between words suffice to account for recall, thus making the concept of meaning per se unnecessary.

By introducing a delay in recall, Experiment I (with 90 Ss) extended Miller and Selfridge's immediate-memory method to that of retention. The hypothesis that recall increases with the order of approximation to English is supported within the limits of the material used. With short-range associations held constant (identical) in Experiment II (with 86 Ss), it was predicted that in two similar passages of some length, the one with more meaning would show greater recall; but that there would be no difference between the short passages lifted from the respective whole passages (Miller and Selfridge's condition). Both predictions are confirmed. Delay in recall in Experiment I and length of passage in Experiment II produce similar results. The results are interpreted as being negative to the hypothesis of the sufficiency of short-range associations to account for recall.

128. Hanawalt, N. G. & Tarr, A. G. The effect of recall upon recognition. Journal of Experimental Psychology, 1961, 62, 361-367.

The effect of interpolated recall upon recognition was measured at different time intervals: immediately following recall and 48 or 52 hr. after recall. The learning was incidental in the form of a true-false test and recognition was measured by a multiple choice test. Interpolated recall produced some equivocal evidence for a facilitating effect of recall upon recognition when recognition followed immediately after recall; when recognition was delayed 48 or 52 hr., the facilitating effect was unequivocal. A test of the hypothesis that in recognition better known items have a depressing effect upon worse known items produced negative results. The effect of both erroneous and correct recall was found to increase with the lapse of time. The disagreement of the present results with some recent studies showing a depressing effect of recall upon recognition is discussed in the light of possible factors accounting for the differences. More research is needed before it will be possible to predict when recall will have a facilitating, a depressing, or no effect upon recognition.

129. Harris, C. S. & Haber, R. N. Selective attention and coding in visual perception. Journal of Experimental Psychology, 1963, 65, 328-333.

The form of S's silent verbal encodings of briefly presented stimuli was manipulated. Order of encoding accounted for the effects of instructions to attend selectively on accuracy of report. Instructions to attend selectively had no significant effect on Ss who encoded the stimulus in the order dictated by English syntax. The Ss whose coding strategy permitted them to encode first the stimulus attribute they were told to attend to reported this attribute more accurately than incidental attributes. The superior accuracy was not a by-product of order of report. The attribute encoded first is based on a better visual trace and also may be retained better in short-term memory.

130. Harris, G. J. & Lown, B. Inter-item time distribution and response compatibility in the short-term serial retention of digits. Psychonomic Science, 1968, 10(3), 295-296.

Twenty digits were presented sequentially during a 40 second display period. Three conditions of inter-item time distribution and three conditions of compatibility of answer sheet forms were employed in a 3 by 3 factorial design. The 20 digits were either distributed evenly over time, in two groups of 10 digits with a 20 sec rest between groups, or in three groups of 6, 7, and 7 digits with 10 sec rests between groups. Three levels of compatibility consisted of answer sheets containing either 20 equally spaced answer blanks, two groups of 10 blanks, or three groups of 6, 7, and 7 blanks. Results showed an interaction between the two variables. In addition, serial position curves showed multi-bowing effects which suggested both input and output anchoring.

131. Harrison, G. Some additive results in short-term memory. Acta Psychologica, 1967, 306-315.

The recall of multiattributive lists by 40 subjects is reported. In the experiment a multiattributive list was one in which both values of 2, 3, or 4 binary attributes (e. g. attribute Side with values Left, Right) appeared twice over all four list items. Relevant recall concerned only attributes for which both binary values appeared. It was found that performance for three attributes when four were relevant could be predicted. The basis of these predictions was an additive approach. It involved overall performance with lists in which four attributes were relevant at recall, and performance with separate attributes of lists in which only three attributes were relevant at recall.

132. Hart, J. T. Memory and the memory-monitoring process. Journal of Verbal Learning and Verbal Behavior. 1967, 6, 685-691.

Two experiments are reported that attempt to evaluate whether people can accurately monitor the contents of their memories when they are unable to retrieve those memories. Both experiments used recently learned paired-associates as memory materials: Ss were asked to predict which unrecalled response items they would be able to recognize by referring to their feelings of knowing about the missing items. The results show that the Ss were able to make relatively accurate predictions about recognition failures and successes. The general process revealed by the findings (called the memory-monitoring or MEMO process) is discussed in relation to recall and recognition thresholds.

133. Heilyer, S. Supplementary report: frequency of stimulus presentation and short-term decrement in recall. Journal of Experimental Psychology, 1962, 64, 650.

134. Helms, D. L. & Kiltz, B. L. The effect of rate of presentation of paired associates on short-term retention. Journal of Psychology. 1965, 60, 147-154.

135. Hinrichs, J. V. Short-term memory with a guessing technique. Journal of Experimental Psychology. 1966, 71, 89-95.

A guessing technique was applied to the short-term retention of serially presented items in 3 experiments. The major features of the guessing technique (Experiment I) were found to be (a) an increase in forgetting with an increase in the number of interpolated items, (b) the relative lack of a similar influence with the number of prior presentations, and (c) the improvement in guessing within each trial. The amount of forgetting was also found to be a direct function of the size of the to-be-remembered item (Experiment II) and a direct function of the rate of presentation (Experiment III).

136. Hintzman, D. Classification and aural coding in short-term memory. Psychonomic Science, 1965, 3, 161-162.

Analysis of errors in a short-term memory task indicates that Ss adopted two possible coding strategies: digit vs. letter categorization and subvocal or aural rehearsal. White noise had no effect on types of errors made or an overall performance, but did bring out the usually covert rehearsal process. Evidence from errors and effects of noise point to a reinterpretation of "auditory" coding in terms of kinesthetic feedback produced by subvocal rehearsal.

137. Hintzman, D. L. Articulatory coding in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 312-316.

Confusion errors in short-term memory for visually-presented nonsense syllables were analyzed to determine the influence of two articulatory features of consonants: voicing and place of articulation. Both were found to contribute to confusions. Results are interpreted as consistent with a hypothesis of mediation by kinesthetic cues arising from subvocal rehearsal, and inconsistent with a hypothesis of mediation by an auditory image.

138. Hodge, M. H. & Fox, W. F. Irrelevant information and probability of recall in sequential short-term retention. Paper read at American Psychological Association, Philadelphia, September 1963.

139. Hodge, M. H. & Fox, W. F. Sequential short-term retention as a function of probability of recall of category items. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 228-233.

Sixty college students were asked to perform a sequential retention task in which the probability of recall (PR) of the stimulus words from 0, 2, or 4 categories was either .00, .25, .50, .75, or 1.00. All Ss, equally divided among the three category conditions, were presented 16 sequences of 24 items (4 sequences for each PR) on each of four successive days. Increases in PR and increases in the number of categories in which PR < 1.00 led respectively to significant decreases and increases in the mean proportion of correct responses at recall. It was suggested that variations in PR and in the number of categories affect performance by producing differential information-processing demands on S.

140. Horowitz, L. M., Brown, Z. M. & Weissbluth, S. Availability and the direction of associations. Journal of Experimental Psychology, 1964, 68, 541-549.

This article reports evidence that a verbal association is symmetrical if its units are equally available. An item's availability was increased by having S produce it from memory. By the PA method S learned pairs of disyllables, which together formed an associative structure. The stimuli of some pairs were responses in other pairs; these stimuli thus became available. S was then asked for 2 free associations to every disyllable. Four conclusions were drawn from the response hierarchies: (a) Available items occurred more often as responses in all hierarchies. (b) A backward association occurred as readily as a learned forward association if the PA stimulus was available. (c) Associations occurred between items that had shared a common associate, even though these items had not coappeared. Such associations, however, only manifested themselves when their response was available. (d) The data did not support a simple principle of mediation as an explanatory concept.

141. Horowitz, L. M., Norman, S. A. & Day, R. S. Availability and associative symmetry. Psychological Review, 1966, 73, 1-15.

This paper examines the concept of availability and its theoretical role in the cognitive processes. An item's availability (AV) is operationally defined by the probability that S could recall it after a 15-second delay. (AV seems to grow fastest when S produces it from memory. It also grows, though not as fast, when S sees the item without producing it.) This definition is used to examine the principle of associative symmetry, and evidence is presented to support it. Sources of asymmetry in natural language are examined, and the concept's theoretical implications for memory and thought are discussed.

142. Horowitz, L. M. & White, M. A. Producing symmetrical associations. Proceedings of American Psychological Association, 1965, 1, 31-32.

143. Howat, M. G. The human brain as an information processor. CAL Report No. FDM-357, Cornell Aeronautical Laboratory, Inc., Buffalo, New York, 1965.

144. Howe, M. J. A. Intra-list differences in short-term memory. Quarterly Journal of Experimental Psychology, 1965, 17, 338-342.

Subjects attempted to recall lists of nine consonants immediately after presentation. Using various recall orders it was found that recall of part of a list interfered with retention of the other parts, memory for items presented early in a list being less affected by such interference than was that for later items. Since this result was not obtained when rate of presentation was increased, it is suggested that rehearsal contributed to the greater stability of early items.

145. Howe, M. J. A. A note on order of recall in short-term memory. British Journal of Psychology, 1966, 57(3-4), 435-436.

146. Howe, M. J. A. Consolidation of word sequences as a function of rehearsal time and contextual constraint. Psychonomic Science, 1966, 4(10), 363-364.

This study aimed to examine the effects of contextual constraint (CC) on short-term memory for words. Twenty-four Ss read and then rehearsed lists of 6 words which were either random or second-order approximations to English. They carried out a subtracting task before attempting recall of each list. Recall varied directly with time available for rehearsal (0, 3 and 6 sec. being used). At all rehearsal times constrained sequences were better recalled than randomly ordered word lists. A construction-at-recall explanation is not entirely satisfactory, and it is suggested that CC also affects the way in which lists are stored.

147. Howe, M. J. A. Digram-frequency and immediate memory. British Journal of Psychology, 1967, 58, 57-62.

Digram structure is a determinant of immediate memory for consonant lists. Its effects might operate either before or after recall is required, or both. If digram frequency affects the way sequences are stored, a distracting task may have unequal effects on lists containing digrams of high and low frequency. Two experiments were carried out, which produced evidence suggesting that digram frequency influences the way in which sequences are stored prior to recall being required. When letter sequences were presented between presentation and recall of consonant lists consisting of medium-frequency digrams, recall of the latter was positively related to the digram frequency of the interfering sequences.

148. Howe, M. J. A. Consolidation in short-term memory as a function of rehearsal. Psychonomic Science, 1967, 7(10), 355-356.

In tests of short-term memory, intra-list differences have been observed in the extent to which accuracy of recall of items is affected by interfering events. No such differences occurred when all items were equally rehearsed, which suggests that the intra-list differences in resistance to interference were caused by differential rehearsal of items during presentation.

149. Howell, W. C. & Tate, J. D. Influence of display, response, and response set factors upon the storage of spatial information in complex displays. Journal of Applied Psychology, 1966, 50, 73-80.

Immediate recall for spatial information was studied as a function of stimulus load under 2 display formats, 2 response formats, and 2 response set conditions. Four groups of 10 Ss each served under 15 replications of all response-format, stimulus-load conditions; groups were distinguished on the basis of display format and set. Each S viewed either a spatial or tabular display of 14-26 geometrical stimuli for 16 seconds; he was then required to report - on either a tabular or spatial response form - the location of relevant stimuli. Correct responses and misplacement errors increased more rapidly for the spatial format as more stimuli were presented. Recoding from 1 display to the other response format did not yield serious decrements. Contrary to expectation, response set enhanced all conditions to a nearly equivalent degree. Results are interpreted in terms of the "chunking" hypothesis.

150. Hunt, E. B. Simulation and analytic models of memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 49-59.

151. Inglis, J. & Tansey, C. L. Perception and short-term storage in dichotic listening performance. Psychonomic Science, 1967, 7(8), 273-274.

Alternative hypotheses have been put forward to account for order-effect in dichotic listening performance. One of these involves a distinction between perceptual and short-term storage mechanisms, the other requires only different storage mechanisms. If the distinction between perception and storage may be regarded as related to the difference between activity traces and structural traces, then the repeated digit series technique devised by Hebb (1961) offers a means of testing these alternatives. Results suggest that a single, rather than a dual mechanism underlies order-effect in the sequential recall of simultaneous stimuli.

J

152. Jahnke, J. C. Serial position effects in immediate serial recall. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 284-287.

This study examined the effects of serial position and length of series on immediate serial recall. Arrangements of either 5, 6, 7, 8, or 9 English consonants were presented according to latin-square designs to groups, respectively, of 20, 18, 21, 24, and 18 women college students. Bowed serial position curves of recall typical of serial anticipation learning were obtained on the first trial for each of the series of different lengths, except for the 5-consonant series, for which recall was perfect. Recall was poorer and bowing of the serial position curve was greater as the length of series increased. Attention was directed to the similarity between the serial effects of immediate memory and rote serial learning.

153. Jahnke, J. C. Primacy and recency effects in serial-position curves of immediate recall. Journal of Experimental Psychology, 1965, 70, 130-132.

Each of 48 college students were read lists of 6, 10, and 15 English words in counterbalanced order. Half the Ss were given instructions for the immediate serial recall of the lists; the remaining, immediate free recall. Mean percentage correct recall was found to be higher for conditions of free than serial recall and for shorter than longer lists. Serial-position curves showed that recency effects, relative to primacy, were stronger for free than serial recall and for longer than shorter lists. Frequency of recall appeared to be more closely related to order of emission of an item during recall than to its order during presentation.

154. Jahnke, J. C. & Davidson, W. R. The effects of three temporal variables on short-term memory for paired associates. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 946-949.

A total of 189 Ss was given, in alternation, three study and three recall trials on each of six lists of six paired associates each. Ss were assigned in equal numbers to 21 experimental conditions, which represented all possible combinations of seven conditions of stimulus and pair durations on study trials and three conditions of stimulus duration on recall trials. Performance increased with increases in each of the three temporal variables on Trial 1 and Trials 2-3 and 1-3 combined. These results were related to those of rote verbal learning and were taken to support the notion of a continuity between the phenomena of short-term memory and those of a longer-term memory deriving from multiple presentations of materials.

K

155. Kaplan, I. T. & Carvelas, T. Scanning for multiple targets. Perceptual and Motor Skills, 1965, 21, 239-243.

Subject scanned a list of random letters looking for 1 to 5 target letters, which were read to him just before the list was presented. His scanning rate was estimated from a graph of the time required to find a target at different positions in the list. The more targets S was seeking, the more slowly he scanned. The time spent processing each non-target letter in the list increased in direct proportion to the number of targets for which S was searching.

156. Kaplan, I. T., Carvelas, T., & Matlay, W. Visual search and immediate memory. Journal of Experimental Psychology, 1966, 71, 488-493.

Two experiments examined the relationship between search time and number of targets searched for. The 1st experiment photographed S's eye movements as he compared 2 groups of letters to determine whether one was a subset of the other. The time spent searching the containing set increased in proportion to the number of target letters it contained. In this case, search time included the time spent recognizing all the targets. The 2nd experiment photographed S's hand movements as he canceled just-learned target letters in English text. Here search time was measured so that it excluded the accumulation of recognition times. Search time still increased with the number of targets being sought.

157. Kaplan, G. A., Yonas, A., & Shurcliff, A. Visual and acoustic confusability in a visual search task. Perception and Psychophysics, 1966, 1, 172-174.

Visual and acoustic confusability between a target item and background items was varied in a visual search task. Visual confusability was a highly significant source of difficulty while acoustic confusability had no effect. The results do not seem to be interpretable within a theory which assumes compulsory auditory encoding of visual information.

158. Katz, L. A technique for the study of steady-state short term memory. Psychonomic Science, 1966, 4, 361-362.

Steady-state STM was studied by a method in which S was required to keep track of the randomly changing response member of each of 5 stimulus words. On each of 220 consecutive presentations, S had to recall the response last paired with a given stimulus and then had to learn a (possibly) new response to the same stimulus. A measure of S's STM was his proportion of correct recalls as a function of the number of items intervening between successive appearances of a given item. Results suggest that the method gives a stable measure of STM. Specifically, proactive effects appeared to be constant throughout the sequence of presentations.

159. Keele, S. W. & Chase, W. G. Short-term visual storage. Perception and Psychophysics, 1967, 2(8), 383-386.

The delay between the offset of a briefly exposed array of letters and digits and the onset of an arrow pointing at one of the array positions was varied from 0 to 5000 msec. In addition, the luminance of the stimulus array was varied over three levels. The Ss reported the item in the position indicated by the arrow. Luminance, delay, and the luminance by delay interaction were all significant. Performance monotonically decreased from a delay of 0 msec to a delay of 250 msec, but the percent correct remained fairly constant from 250 msec to 5000 msec. With delays shorter than 250 msec, high luminance arrays showed better performance.

160. Keppel, G. Facilitation in short- and long-term retention of paired associates following distributed practice in learning. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 91-111.

The experiments to be reported represent an investigation of the conditions of learning under which the retention of verbal materials may be increased. Although the empirical and theoretical background for this study stems from experiments involving the long-term retention, e.g., after 24 hours, of paired-associate lists, the analyses leading to the explanations offered are often based, in fact, upon an analysis of individual pairs. Therefore, the present investigation, in addition to providing further tests of these explanatory concepts under conditions of long-term retention, also involves a test of the same concepts with single paired associates and short-term retention (e.g., after 30 sec.).

161. Keppel, G. Problems of method in the study of short-term memory. Psychological Bulletin, 1965, 63, 1-13.

Considerations of design which have been problems in the study of long-term memory are discussed in the context of short-term memory research. These problems include the type of experimental design (independent versus repeated measures), the measurement of immediate retention, and the means by which the retention interval is filled. This review indicates that these methodological problems are also present in the investigation of short-term memory.

162. Keppel, G. & Rehula, R. J. Rate of presentation in serial learning. Journal of Experimental Psychology, 1965, 69, 121-125.

Serial-learning performance was studied under 2 rates of presentation, 2 and 4 seconds. Following the attainment of criterion (5/14 and 10/14) presentation rate was either switched to the other rate or not switched. A final condition consisted of an alternation of 2-and 4 sec. trials. Although criterion was reached more rapidly under the 4-sec. rate, the total learning time required did not differ between the 2 rates. Performance on the postcriterion trials was primarily a function of the rate of presentation on the postcriterion trials with the precriterion rates having limited influence over the postcriterion trials.

163. Keppel, G. & Underwood, B. J. Reminiscence in the short-term retention of paired-associate lists. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 375-382.

In the first experiment, 5-item paired-associate lists, varying in response-term meaningfulness (high, medium, and low), were presented for a single study trial (4 sec per pair), with recall being taken after 4, 19, 64, 184, and 304 sec. Reminiscence was found at each level of meaningfulness, with the peak of the three retention functions occurring at 19 sec. Three additional experiments established the reliability of the reminiscence effect. Subsequent analyses support the conclusion that either individual differences in rate of learning are important for producing reminiscence or that degree of learning is important.

164. Kernooff, P., Weiner, B. & Morrison, M. Affect and short-term retention. Psychonomic Science, 1966, 4, 75-76.

The effects of motivation on retention were investigated. Using a short-term memory technique, stimuli were cued for different incentives. At a short time interval there were no differences in recall as a function of the incentive condition. However, after a longer interval, stimuli associated with a five cent reward or shock were recalled significantly more than stimuli for which neither shock nor money was a potential outcome. It was argued that motivation did not affect the strength of original learning, but did influence the temporally subsequent process of trace storage.

165. King, D. J. Immediate memory of connected meaningful material practiced under delayed auditory feedback. Psychological Reports, 1963, 13, 91-96.

Sixty Ss were run in two experimental and four control conditions. The task was the recall of a 221-word length story immediately following Ss' reading of the story. The experimental groups were subjected to a 0.2-sec. delayed auditory feedback for the middle section of the story. In addition to the expected decrease in reading rate, the accuracy of recall for the section of the story read under delayed auditory feedback was significantly poorer than the recall of the control groups.

166. King, D. J. Note on delayed auditory feedback, exposure time and retention. Perceptual and Motor Skills, 1965, 21, 497-498.

Two groups of Ss, matched on reading rate, were exposed to the learning material for the same length of time. The experimental group practiced under conditions of delayed auditory feedback, the control group did not. The immediate retention of learned material was significantly poorer in the experimental group. The inhibition on immediate recall of connected meaningful material by delayed auditory feedback cannot be accounted for as a function of the decreased reading rate and resultant greater exposure duration to the learning material.

167. King, D. J. & Dodge, A. The influence of oral recall on immediate and delayed memory for meaningful material practiced under delayed auditory feedback. Journal of Psychology, 1965, 59, 141-147.

Three groups of Ss read a five-paragraph story. One group read the middle paragraph under conditions of .2-second DAF. The other two groups functioned as control groups. Both an immediate and a delayed oral recall were obtained. The usual changes in reading rate were observed. Immediate memory for the material presented under DAF was severely impaired. Delayed retention showed a marked relative increase, but not enough of an absolute increase to eliminate the significant difference between the experimental and the control groups.

168. King, D. J. & Walker, H. J. Effect of prompting on the immediate recall of meaningful material practiced under delayed auditory feedback. Perceptual and Motor Skills, 1965, 21, 438-488.

Eighty Ss were divided into four groups. The two experimental groups read the stimulus story under conditions of DAF, and the two control groups were not so treated. One set of the control experimental groups was questioned regarding the content of the story immediately following the reading and before a recall was obtained (this was called the prompt procedure). The other groups recited the story immediately after reading it and were then prompted on those points not covered in their recall. There were significant differences between control and experimental groups on both indicants of accuracy of retention.

169. King, D. J. & Wolf, S. The influence of delayed auditory feedback on immediate and delayed memory. Journal of Psychology, 1965, 59, 131-139.

Forty-two Ss were run in one experimental and in two control conditions. The Ss recalled a short story immediately after reading it and again 24 hours later. All Ss were monitored on two physiological variables during reading. The experimental group was subjected to a 0.2-second delayed auditory feedback in the middle section of the story. One control group received no special treatment; the other received shock at the point in the story at which the experimental group received delayed auditory feedback. Both the experimental group and the control group that received shock showed marked changes in GSR measurements during the reading of the middle section of the story. The immediate memory of the story was significantly poorer for the experimental group as contrasted with that for each of the control groups. For accuracy of delayed memory, there were no significant differences among the three groups.

170. Kintsch, W. The effects of repetition on the short-term memory function. Psychonomic Science, 1965, 2, 149-150.

Lists of stimulus items were constructed in such a way that successive presentations of items were always separated by one intervening item for one group of items and by 10 intervening items for another group. The S's task was to decide whether he had seen each item before. The amount of forgetting which occurred between presentations was determined both for the short- and long-delay items as a function of the repetition of these items.

171. Kintz, B. L. & Zaffy, D. J. Short-term and long-term retention and task difficulty. Journal of Psychology, 1965, 59, 229-232.

Forty Ss were required to learn two lists of paired associates (an "easy" list and a "difficult" list). A modified anticipation method allowed measures of short-term and long-term retention to be taken. Item difficulty had no effect on STR, but had a large effect upon LTR. The data were interpreted to indicate that two distinct memory mechanisms are involved in the two retention durations.

172. Kintz, B. L. Short-term retention and long-term retention as a function of practice. Journal of Psychology, 1965, 59, 309-314.

Little experimental work has been done relating STR and LTR. In the present study, three STR intervals and three LTR intervals were used with varying numbers of trials (with recall measures after each trial). The task was an easy paired-associates task (with dissyllables as responses and the first letter of the dissyllable as the stimulus). The results show that forgetting increases as the retention interval increases, and that forgetting decreases as the number of repetitions increases.

173. Klemmer, E. T. Does recoding from binary to octal improve the perception of binary patterns? Journal of Experimental Psychology, 1964, 67, 19-21.

Four Ss were trained to report a tachistoscopically flashed binary pattern in terms of octal digits. The patterns were formed on 21 small light bulbs arranged in 7 groups of 3 each along a straight line. Little or no improvement in performance was produced by training Ss in binary-to-octal recoding even after considerable practice.

174. Koestler, A. & Jenkins, J. J. Inversion effects in the tacnistoscopic perception of number sequences. Psychonomic Science, 1965, 3, 75-76.

Experience suggests that a common error in processing visual sequences is inversion or transposition of two or more adjacent items. This phenomenon suggests that information concerning the identify of items and their positions may be partially separable. A perception experiment was performed with tachistoscopic

exposure of 5, 6, and 7-digit sequences. Abundant evidence was found for transposition errors. Further, such errors were distributed in a serial position curve much like that found for errors of single items.

175. Kolers, P. A. Interlingual facilitation of short-term memory. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 314-319.

The probability of recalling a word from a long list of unconnected words increases monotonically with its frequency of occurrence. This facilitating effect of repetition upon recall is found to occur interlingually. The probability of recalling a word when it and its translation are presented $\frac{1}{2}$ times in each of a bilingual's two languages is approximately equal to its unilingual presentation $\frac{1}{2}$ times. Since the words in the two languages are usually phonetically and visually distinct, it appears to be their conceptual identity that permits the facilitation.

176. Korn, J. M. & Jahnke, J. C. Recall and recognition as measures of immediate memory. Psychological Reports, 1962, 10, 381-382.

Using both a measure of recall and one of recognition, immediate memory spans for digits, consonants, high-(HAS), and low-association value nonsense syllables (LAS) were determined for 48 college students in a balanced Latin square design. The measure of recognition was associated with greater immediate retention than was the measure of recall. For either response measure, retention was a function of the class of material to be retained. A comparison of the nonsense materials showed that HAS was better recalled than LAS.

177. Korn, J. H. & Lindley, R. H. Immediate memory for consonants as a function of frequency of occurrence and frequency of appearance. Journal of Experimental Psychology, 1963, 66, 149-154.

This study provided a test of the effect of 2 kinds of frequency on immediate memory for consonants. It was found that the number of consonants correctly recalled increased significantly with an increase in the frequency with which the consonant occurred in the English language (frequency of occurrence) and also with an increase in the frequency with which it appeared on any one trial during the experiment (frequency of appearance). The interaction was not significant. Errors from within a stimulus item occurred much more often than extraitem errors. The "spew hypothesis" of Underwood and Schulz was used to explain the differences in the frequency data. Analysis of the error data also provided further evidence for the existence of a response selector mechanism.

178. Krulee, G. K., Gapp, A., Landi, D. M. & Manelski, D. M. Organizing factors and immediate memory span. Perceptual and Motor Skills, 1964, 18, 533-548.

In a series of four experiments, the processes used in decoding visual inputs were studied, with particular attention given to the influence of organizing factors in immediate memory span. In one experiment, the effect of variations in the number of alternatives per item of input was studied. In a second, the effect of different grouping procedures was evaluated. In a third, variations in internal organization of the input strings were introduced in order to show that recoding is more likely when naturally pronounceable units are available. The final experiment focused on the effect of prior knowledge of the length of the stimulus strings. The results confirmed the difficulty of applying informational measures to immediate memory span and the importance of other variables that influence the ability of Ss to recode complex inputs into more manageable units.

179. Kuennapas, T. Acoustic perception and acoustic memory of letters: Multidimensional ratio scaling and multidimensional similarity. Reports from the Psychological Laboratory, The University of Stockholm, No. 218, November 1966.

The similarities of the acoustic perception and the acoustic memory of nine letters of the alphabet were studied by direct multidimensional ratio scaling and by the method of multidimensional similarity analysis. Three factors were found which were exactly the same in respect of both perception and memory of these letters, and with nearly identical loadings.

180. Kuennapas, T. Visual perception of capital letters: Multidimensional ratio scaling and multidimensional similarity. Scandinavian Journal of Psychology, 1966, 7, 189-196.

The quantitative similarity of nine capital letters was studied (1) by the direct multidimensional ratio scaling method and (2) by the method of similarity analysis. Three factors, 'E', 'O' and 'I', were found. Factor loadings were nearly identical in both methods. A previously proposed equation did not describe the relation between subjective similarity and angular separation of percept vectors.

181. Kuennapas, T. Visual memory of capital letters: Multidimensional ratio scaling and multidimensional similarity. Perceptual and Motor Skills, 1967, 25, 345-350.

The similarity of 9 capital letters, as judged on the basis of visual memory, was studied by direct multidimensional ratio scaling and by the method of similarity analysis. Three factors were isolated which were exactly the same as previously found in perception of these capitals and with nearly identical loadings.

182. LaBerge, D. & Winokur, S. Short-term memory using a visual shadowing procedure. Psychonomic Science, 1965, 3, 239-240.

Lists were constructed with digits serving as buffers and consonant items as targets, the targets being placed at various intervals from the end of the lists. All items were colored either red or black and Ss called out the color of the characters at a fast rate. At the end of each list Ss attempted to recall the consonant target item. Short-term memory functions were obtained which yielded a high recall rate at the zero retention interval and relatively low recall rate after a 6 sec. retention interval.

183. Lachman, R., Laughery, K. R., & Field, W. H. Recognition and recall of high frequency words following serial learning. Psychonomic Science, 1966, 4, 225-226.

A set of 50 words relatively devoid of sequential dependencies (in random order) were administered with degree of training varied for independent groups of Ss. A single test of recall or recognition followed. For most of the range of training, recognition was superior to recall; but with a sufficiently large number of trials, recall surpassed recognition. The results, taken together with previous data, suggest that studies comparing different retention measures by simple ordering are likely to become exercises in futility. Implications were briefly examined for the hypothesis of a unitary construct underlying recognition and recall.

184. Lachman, R. & Tuttle, A. V. Approximations to English (AE) and short-term memory: Construction or storage? Journal of Experimental Psychology, 1965, 4, 386-393.

Free recall improves with increasing contextual constraints on verbal material. Three experiments sought to localize the facilitation at stimulus reception, storage, and/or retrieval. The construction hypothesis assumes associative and grammatical reconstruction of a training list during free recall: a retrieval effect. Experiment I compared retention for high and low AE lists on free recall and on a "successive binary recognition test" which precluded output construction. Result, high AE words are stored more efficiently. Experiment II tested for possibility of input construction during faulty stimulus reception as an alternative explanation to storage. Measurements of perceptual error during training failed to support the input-construction hypothesis. Evidence for output construction was slight but supported a prediction of instructional control of output-construction behavior. Experiment III demonstrated reproducibility and generality of results. Conclusions: (a) the human storage system is biased for high AE material, (b) recognition errors are lawful, false-positive error means are proportional to number of distracters, yielding a .19 constant.

185. Laughery, K. R. & Pinkus, A. L. Effects of acoustic similarity, presentation rate and presentation mode. Psychonomic Science, 1966, 6, 285-286.

The effects of four variables on short-term memory were studied: Presentation Rate (20, 60 or 180 items/min.), Presentation Mode (visual or auditory), Acoustic Similarity (High, BCDEGPTVZ or Low, HJLOQRWXY), and Length of Sequence (6 or 8 items). Performance varied inversely with the Length of Sequence and Acoustic Similarity and directly with Presentation Rate. A significant Presentation Rate by Presentation Mode interaction was explained on the basis of less available time for rehearsal at the fast presentation rate due to the time required for the implicit translation from visual input to the storage of auditory cues.

186. Laughery, K. R. & Pinkus, A. L. Recoding and presentation rate in short-term memory. Journal of Experimental Psychology, 1968, 76, 636-641.

The relative effectiveness of meaningfulness and pronounceability as dimensions for recoding into larger chunks was studied using a memory-span task. Sequences of 12 letters were used in which the items made up 4 units that were 3-letter words (meaningful-pronounceable), familiar 3-letter abbreviations such as IBM (meaningful-unpronounceable), or 3-letter CVC's (meaningless-pronounceable). The 4th condition (meaningless-unpronounceable) consisted of letters that were arranged so as to minimize groupings that were meaningful or pronounceable. The letters were presented at 5 different rates: 1 item every .3, .6, 1.0, 2.0, or 3.0 sec. Performance significantly increased in the order meaningless-unpronounceable, meaningful-unpronounceable, meaningless-pronounceable, and meaningful-pronounceable. Recall varied inversely with presentation rate. A significant interaction occurred between meaningfulness and presentation rate, with the effect of meaningfulness decreasing at the fastest rate. The results are explained on the basis of rehearsal efficiency and the availability of additional cues where the units are meaningful.

187. Lawrence, D. H. & Coles, G. R. Accuracy of recognition with alternatives before and after the stimulus. Journal of Experimental Psychology, 1954, 47, 208-214.

Sixty Ss, divided into three groups of 20 each, were shown tachistoscopically presented pictures at various exposure intervals and asked to identify them. The control group had no alternatives presented to it, whereas the two experimental groups each had a set of four alternatives specified for each stimulus. One experimental group had the alternatives presented before the stimulus exposure and the other group following the exposure. The alternatives were of two types: (a) SA, or very similar alternatives all suggesting perceptually similar objects, and (b) DA, or discrete alternatives all suggesting perceptually different objects. The results and the interpretations made were as follows:

1. The two groups with alternatives were superior to the control group without alternatives in accuracy of recognition even when allowance was made for guessing.

2. Alternatives before and after the stimulus facilitated recognition to an equal extent.

3. The facilitative effect of DA was consistently greater than that of the SA at all exposure times, but there was no evidence of an interaction effect between the type of alternative and when it was presented in relation to the stimulus exposure.

4. These results tend to rule out the hypothesis that the facilitative effect of alternatives results from an actual modification of perception and support the hypothesis that they operate either on the memory trace or response aspects of the recognition process.

188. Lewis, M. E. & Teichner, W. H. The effect of various modes of rehearsal on short-term memory. Technical Report NAVTRADEVVCEN 1303-1, U. S. Naval Training Device Center, Port Washington, New York, 1963.

This report is one of 3 evaluations of differently proposed methods for increasing the ability of individuals to report the contents of briefly exposed alphabetic displays. In this case study was made of the effects on short-term recall of the last and next last display in a rapid series of the following modes of rehearsal: (1) silent rehearsal, (2) vocal rehearsal, (3) manual rehearsal, (4) combined vocal-manual rehearsal. The results suggested that rehearsal aids when memory is severely stressed, as for recall of the next last display, and that vocal rehearsal is superior to the other modes studies. The military implications of the results are discussed.

189. Lindley, R. H. Effects of controlled coding cues in short-term memory. Journal of Experimental Psychology, 1963, 66, 580-587.

Three experiments investigated the effects of the presence or absence of recoding and decoding cues on short-term memory (STM) for 3-letter items. The retention intervals were 3, 13, 39 sec. in Experiments I and II; 3, 12, 36 sec. in Experiment III. The Ss were 36 men and women in Experiment I, 24 in Experiment II, 30 in Experiment III. The results were (a) that recoding cues facilitated STM with low meaningfulness but interfered with STM with high meaningfulness ($p < .01$), (b) decoding cues facilitated STM with low meaningfulness ($p < .01$).

- .90. Lindley, R. H. Effects of trigram-recoding cue complexity on short-term memory. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 274-279.

In Exp. I the retention intervals were 0, 8, 20, and 32 sec; a trigram was presented either twice or was followed by an easy-to-decode (ED) recoding cue (e.g., CAG-Cage) or by a difficult-to-decode (DD) cue (e.g., CAG-Caught); the trigrams were either of high (HM) or low (LM) meaningfulness. The Ss were 24 men and women. The results (at $p < .01$) were that: (a) retention intervals, meaningfulness, the presence of recoding cues, and ease of decoding were statistically significant. In Exp. II the same retention intervals were used; the trigram was either presented twice or preceded or followed by an ED cue; the trigrams were either of HM or LM. The results (at $p < .01$) were that retention intervals, recoding cues, and the meaningfulness by recoding cues interaction were statistically significant. The results showed that (a) in general the presence of recoding cues facilitated memory, (b) ED items had more of a facilitative effect on memory than DD items, (c) when the necessity for S to recognize the ED relationship was eliminated, recall of LM trigrams with recoding cues present was equal to recall of HM trigrams with cues present.

191. Lindley, R. H. Recoding as a function of chunking and meaningfulness. Psychonomic Science, 1966, 6, 393-394.

Trigrams of high or low meaningfulness were paired with 1-chunk or 2-chunk recoding cues in short-term memory. The presence of either 1-chunk or 2-chunk cues reduced but did not eliminate the effects of meaningfulness on trigram recall.

192. Lindley, R. H. Words and pronunciation as coding aids. Psychonomic Science, 1966, 6, 395-396.

In Experiment I after an initial presentation of 1 or 2 to-be-recalled trigrams, E either spelled the items, pronounced them, or said related words. Pronunciation did not facilitate recall, whereas the related words did. Experiment II showed that the failure to find facilitatory effects of pronunciation in Experiment I was due to whether E or S did the spelling and pronouncing.

193. Lindley, R. H. & Nedler, S. H. Further effects of subject-generated recoding cues on short-term memory. Journal of Experimental Psychology, 1965, 69, 324-325.

Forty-eight men and women college students were tested in a short-term memory (STM) study using the Peterson and Peterson (1959) technique. All Ss were tested with 4 retention intervals, high- or low-meaningfulness (HM or LM) items, and 2 presentations of the trigram or recoding cue preceding or following the trigram. Twenty-four Ss recalled both the trigram and the recoding cue; 24 recalled only the trigram. Major results were (a) recoding cues in either order facilitated

trigram recall; (b) recalling both the trigram and the recoding cue had no effect on trigram recall as compared to recalling the trigram alone; (c) correct recall for LM recoding cues was 93 percent, for HM cues 92 percent.

194. Lloyd, K. E. Supplementary report: Short-term retention as a function of average storage load. Journal of Experimental Psychology, 1961, 62, 632.

195. Lloyd, K. E. Short-term retention as a function of item frequency. The Journal of Psychology, 1964, 58, 249-253.

The daily frequency of occurrence of items (letter-word pairs) was varied in a sequential memory task. In this task, S continually received information and, at unpredictable moments, was requested to recall some of it. Two groups of Ss which differed in the range of variation in item frequencies in the sequences presented to them were compared. Total recall was directly related to range of item frequency ($p < .01$). High-frequency items in a high-range group were recalled more often than medium-frequency items in a narrow-range group ($p < .01$). Items with a low frequency in both the groups were recalled most often by the highest-range group ($p < .05$). The facilitation of recall in the highest-range groups was not limited to the high-frequency items.

196. Lloyd, K. E. Short-term retention as a function of item value. Perceptual and Motor Skills, 1964, 18, 297-298.

Subjects stored and recalled unrelated words which differed in their penny value (Group I), or which had the same value (Group II). The number of words being stored at any one time was also varied. Recall errors decreased regularly from low to high value words in Group I, and remained relatively constant in Group II. Errors varied directly with the storage load at all word values.

197. Lloyd, K. E. Short-term retention as a function of recall point coding. Psychological Reports, 1964, 14, 752-754.

Recall is facilitated if items to be stored are easily coded into familiar chunks. The means of coding the items is usually obvious at the time they are presented. The purpose of the present study was to learn if recall was facilitated when the basis for coding a stored item was delayed until the time of recall. The results indicated a substantial improvement in recall as the appropriateness of the recall point for the stored item was increased. This improvement varied inversely with the storage requirements of the task.

198. Lloyd, K. E. Short-term retention as a function of word frequency. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 286-289.

The English text frequency of words used in a sequential-memory task was manipulated. In this task S continually received new words to be remembered, and, at unpredictable moments, was requested to recall some of them. Three groups of Ss were compared. One group was presented high-frequency words, another low-frequency words, and a third was presented words which varied in frequency over a wide range. Recall varied as a function of word frequency. Differences in recall were greater when the memory requirements of the task were low than when they were high.

199. Lloyd, K. E. Note on individual storage loads and individual load reductions. Psychological Reports, 1965, 16, 995-996.

Sequential memory tasks require E to construct a sequence of items to be remembered and cues to recall these items. In a series of studies sequences were constructed in terms of the average number of items S was remembering at a recall point and of the average number of items S was asked to recall at a recall point. These averages were based on values assigned to individual items and recall points. The present study systematically varied the distribution of these individual values that formed the averages. Bimodal distributions affected recall differently from symmetrical distributions.

200. Lloyd, K. E. & Johnston, W. A. Short-term retention as a function of contextual constraint. Journal of Experimental Psychology, 1963, 65, 460-467.

Contextual constraint has improved recall in the classic memory span task. Here this variable was manipulated in a sequential memory task in which S continually received information, and, at unpredictable moments, was requested to recall some of it. In Experiment I 24 undergraduates continuously stored an average of 3 or 7 items and recalled them 2 at a time. This required many recall points which interrupted the continuity of contextual passages. The effect of varying contextual constraint was significant ($p < .01$), but small. In Experiment II interruptions were gradually reduced by requesting more and more items per recall point. Recall improved ($p < .01$) as constraint increased and as interruptions decreased; these variables interacted. Interruptions severely curtailed the benefits of context.

201. Lloyd, K. E., Reid, L. S. & Feallock, J. B. Short-term retention as a function of the average number of items presented. Journal of Experimental Psychology, 1960, 60, 201-207.

Short-term retention was studied in a situation requiring S to remember familiar English words until their recall was requested. During the time S was required to remember these items he was presented other words or asked to recall

previously presented items. Three experiments are reported in which the first demonstrated that recall errors increased systematically as the average number of words to be remembered over blocks of recall points, termed average storage load, was increased. The other two experiments further demonstrated that performance was related to average storage load, but was relatively independent of the size of population from which the English that made up the tasks was drawn.

202. Loess, H. Proactive inhibition in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 362-368.

Two experiments investigating short-time retention of individual verbal items were performed. In the first, 72 Ss were tested for retention of each of a series of 12 CCC trigrams after intervals of 9, 18 and 27 sec. In the second, three groups of 24 Ss each were presented a series of 24 trigrams. For one group, retention of each item was measured after 3 sec, for a second group after 9 sec, and for the third group after 18 sec. At 3-week intervals Ss returned to learn additional series of trigrams which were tested at the remaining retention intervals. In both experiments, retention of the first trigram of a series remained constant over all retention intervals, while retention of the second trigram decreased as the length of the retention interval increased. Beyond the second trigram interpretation is complicated by the development of a practice effect. Results support the contention that PI operates in a similar fashion in short-term and in long-term memory and indicate that much of the forgetting observed in experiments using the Peterson technique of presenting and testing single verbal items can be attributed to the development of PI.

203. Loess, H. Short-term memory, word class, and sequence of items. Journal of Experimental Psychology, 1967, 74(4, Pt. 1), 556-561.

One-hundred twenty Ss received 24 word trials in a Peterson-type short-term memory test. Items contained high or low frequency words, were homogeneous or heterogeneous with respect to taxonomic category, and successive tests of a given category were massed or distributed over the trials. When massed, retention was maximum for the first item of a category, significantly poorer in most cases for the second and third; when distributed, no loss occurred for retention of words, a slight loss for intra-item position. Heterogeneous items showed maximum PI after 1 trial. Word frequency did not interact with the other variables. The interpretation is that PI does not develop across taxonomic classes and that within classes it dissipates if items are sufficiently spaced.

204. Loess, H. & Waugh, N. C. Short-term memory and intertrial interval. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 455-460.

Subjects attempted to recall a single word-triad after a 9-second retention interval. The interval between successive tests (each with a different triad) was varied over a wide range. Proactive inhibition was found to decrease as a function of the length of the intertrial interval; when this interval exceeded 2 min, proactive inhibition was negligible. It did not appear to cumulate across a series of several trials.

M

205. Mackworth, J. F. Paced memorizing in a continuous task. Journal of Experimental Psychology, 1959, 58, 206-211.

An investigation was made to discover the number of stimuli that Ss could usefully remember in a simple stimulus-response task. The stimulus was either an alphabetical letter or a light and the response button was labelled with the same letter. The problem was to press the button at the right time in relation to the stimulus. This time was determined by the instructions, which required the response to a certain stimulus to be delayed until a definite number of later stimuli had appeared. In other words, S had to remember a continually changing small group of letters. The size of the group to be remembered was varied from zero to four letters, in addition to the one to which response was being made. The test was scored by determining the speed at which each S could reach an 80 percent correct score.

It was found that Ss required approximately 1 sec. per stimulus for each member of the group which they had to hold in memory. Thus when the response lay five letters behind its stimulus, so that four letters had to be remembered, Ss required 4 sec. per stimulus to achieve the 80 percent performance level. However, not all Ss could reach this level at this Advance 5, and the memory span in such a continually changing serial task was thus about three to four items, under the conditions of the experiment.

Further experiments showed that identifying letters were not necessary for Advances 0, 1, and 2, but were necessary for Advances 3 and 4. These experiments emphasized the difference between remembering one item at a time and remembering more than one.

206. Mackworth, J. F. Presentation rate and immediate memory. Canadian Journal of Psychology, 1962, 15, 42-47.

When eight- or nine-digit messages were presented visually, it was found that increasing the speed of presentation reduced the amount which could be recalled.

207. Mackworth, J. F. The effect of display time upon the recall of digits. Canadian Journal of Psychology, 1962, 16, 48-54.

Subjects were required to recall sets of digits immediately after visual presentation, under varying conditions of message duration and number of digits displayed simultaneously. It was found that when the display variable was constant the amount recalled was proportional to the logarithm of the mean time per digit; when the mean time per digit was kept constant the amount recalled was proportional to the logarithm of the number of digits displayed simultaneously. However, the two

variables were not interchangeable in their effect on the recall score. No evidence was found to support the decay theory when the display was kept constant, but a cross-comparison between different times and displays could be interpreted in support of this theory.

208. Mackworth, J. F. The effect of the response upon the immediate memory span. Canadian Journal of Psychology, 1962, 16, 120-127.

Display and response rates and conditions were varied to study their effects upon the immediate memory span. Recall was better when the whole message of nine or ten digits was presented simultaneously than when presented as separate digits. The introduction of a visual selection factor into the response decreased the amount recalled. This decrease appeared to be due to the difficulty of the selection rather than the time spent on it. It is suggested that the familiarity of the display and response situations may be an important factor in determining the length of the memory span.

209. Mackworth, J. F. Effect of reference marks on the detection of signals on a clock face. Journal of Applied Psychology, 1963, 47, 196-201.

Forty-two female Ss were employed in each of 3 studies undertaken to determine the effect of white marks on a black clock face on the detection of signals, consisting of brief pauses of the clock hand. The signals were presented at intervals ranging from 5-14 sec; 0-30 marks were used. The addition of 1 mark reduced the percentage of missed signals to half that of the blank face ($p < .01$). Least signals were missed when they were near the white mark. Conclusions are the detection of a brief pause in a clock hand is improved by the addition of reference marks and there is a rapid decrease in detection of frequent signals as the run continues.

210. Mackworth, J. F. The duration of the visual image. Canadian Journal of Psychology, 1963, 17(1), 62-81.

When sets of items are displayed for brief periods, information can be extracted from a visual image which remains after the display has disappeared. Experiments were undertaken to investigate the relation of the amount reported from the visual image to various characteristics of the display. These included the exposure duration, the ratio of the luminance between displays, and the number and nature of the items in the display. The study included records of the duration of the response under paced and unpaced conditions.

It was found that when the exposure duration was above a critical level it had little effect on the amount reported from the visual image. This critical level depended on the ratio of the display luminance to the luminance between displays, but above this level the luminance had no effect on the amount reported. When the paced response was compared with the unpaced response, the amount reported after exposure was approximately constant, but the duration of the response was not. When the

response was unpaced, the duration of the response was constant for simple displays of digits, colours, or letters. The amount reported was proportional to the speed of reporting the different items, and it was concluded that the amount reported was limited by the duration of the visual image.

211. Mackworth, J. F. The relation between the visual image and post-perceptual immediate memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 75-85.

These experiments investigated the relations between immediate recall of visually presented digits, letters, colors, and shapes and various methods of presentation, in order to illustrate the use of a simple equation which gave a quantitative analysis of the factors involved. This analysis was based on the assumption that the whole of the recall task involved a constant amount of a quantity called the A-factor.

Experiment I compared Single and Block presentation at three speeds (0.25 to 1 sec./item); Experiment II studied Single presentation at slower speeds (1 to 2 sec./item) with shorter messages. Experiment III studied Block presentation at exposures from 0.1 to 6 sec. Eight Ss, housewives, were used for each experiment. The speed of reading the materials was measured. There was a positive correlation for each S between the various measures. Experiment IV examined the effect of message length up to 20 letters upon the recall of letters. The Ss were 12 school girls. The relation between message length and recall could be regarded as a rapid loss of most of the message, followed by a slow loss of the last few items. A linear equation seemed to be a reasonable fit for the first part of the curve. This was $M_a + N_s = 100$, where M = number of items given, and N = number of items recalled.

Experiment V examined the effect of message length upon recall of the four materials. The Ss were ten school girls. The recall loss due to excess material was approximately linear and parallel for the four materials.

It was concluded that report from the 0.1 sec. exposure was made from a rapidly decaying pre-perceptual visual image, and was limited by the speed of recognition, which itself was limited by the same difficulties that affect the post-perceptual immediate recall.

212. Mackworth, J. F. Auditory short-term memory. Canadian Journal of Psychology, 1964, 18, 292-303.

Immediate recall of sets of digits, letters, and colour or shape names presented aurally resembled recall of visual material in the effects of material and message length, but more items were recalled when the messages were presented faster, in contrast to visual presentation. Vocal rehearsal during presentation reduced recall. Ten Ss were tested for each comparison.

213. Mackworth, J. F. Interference and decay in very short-term memory. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 300-308.

Four experiments were conducted comparing the effect of message length on the recall of simple and mixed messages of digits, letters, colors, and shapes, presented visually. (Thirty-five housewives served as Ss). The total correct recall was inversely related to the message length, with slope independent of composition but with intercept determined by the materials presented. The amount lost due to the second kind of material in a message was related to the time taken to read this material.

214. Mackworth, J. F. Presentation rate, repetition, and organization in auditory short-term memory. Canadian Journal of Psychology, 1965, 19(4), 304-315.

Four auditory experiments are described which study the effect of repetition on immediate recall of series of letters or digits. The variables investigated were presentation rate, message length, and organization. Recall from slow presentation differed from fast in nearly all cases, but the differences were complex. With rhythmic presentation, recall was better at the faster presentation rate but showed relatively little improvement with repetition, while there was greater loss of recall with the fast presentation when the message length was increased. With non-rhythmic presentation, recall from the fast single presentation was less, but greater improvement with repetition was noted. These results are discussed in terms of the decay theory.

215. Mackworth, J. F. Perceptual coding as a factor in short term memory.
Canadian Journal of Psychology, 1966, 20, 18-33.

Five experiments are described in which the nature of the presented and recalled items were varied independently. Digits were presented visually as normal, Bankers' or mirror digits, or coded from Japanese characters. Recall of CVC trigrams, presented in written form or coded from the characters, and recall of shape names from visual, auditory, or tactile presentation were compared. The equation $N = c - bM$ appeared to fit the data, where N was the number of items recalled from messages of length M, c varied with the material, but b was approximately constant at about 0.8. It was concluded that the effect of message length (beyond the optimum length) on recall was independent of the material.

216. Mackworth, J. F. & Mackworth, N. H. The overlapping of signals for decisions.
American Journal of Psychology, 1956, 69, 26-47.

217. Madser, M. C. & Drucker, J. M. Immediate memory by missing scan and modified digit span. Psychonomic Science, 1966, 6, 583-384.

The experiment was designed to determine whether the superiority of missing scan over modified digit span retention is due to either storage or retrieval processes. Subjects tried to recall either all numbers or a missing number from finite sets with retrieval method instructions given either before or after stimulus presentation. Results indicate that the relative superiority of missing scan retention is diminished when Ss are instructed after stimulus presentation. Superior retention estimates by the missing scan method were attributed largely to different storage processes under the two conditions.

218. Marcer, D. The effect of presentation method on short-term recall of CCC trigrams. Psychonomic Science, 1967, 8, 335-336.

Short-term recall of single trigrams was measured in a Peterson (1959) type situation comparing three presentation methods, one auditory and two visual. In the visual conditions the stimuli were presented grouped as a three letter unit for 1 second, or spaced letter by letter within 1 second. In the auditory condition Ss heard the stimulus within 1 second. Most efficient recall was in the visual grouped condition, with the visual spaced presentation giving recall approximating to the auditory condition.

219. Marcer, D. A comment on acoustic data and recognition in short-term memory. Psychonomic Science, 1967, 9, 464.

220. Margrain, S. A. Short-term memory as a function of input modality. Quarterly Journal of Experimental Psychology, 1967, 19, 109-114.

The two experiments reported are concerned with short-term memory for digit lists simultaneously presented both auditorily and visually. Results showed (1) that interpolated written and verbal recall differentially affect retention depending on whether the to-be-recalled list was presented auditorily or visually. (2) That input modality appears to be far more important for recall than was directing subjects' attention to a list during input, when that list might or might not have been subsequently required for recall. The results suggest that short-term storage is modality specific. In this case, Broadbent's P and S mechanisms do not adequately describe what happens during simultaneous visual and auditory presentation. Nor would Sperling's suggestion of a final auditory store appear to be supported.

221. Martin, E. Short-term memory, individual differences, and shift performance in concept formation. Journal of Experimental Psychology, 1968, 76, 514-520.

Using simple stimuli generated by 4 orthogonal binary dimensions, 96 Ss solved 2 successive concept-formation problems. Between the 2 tasks, Ss recalled backwardly the most recent stimuli presented. When solution criterion was 8/8, Ss who solved the original task rapidly did not differ from those who solved it slowly in recall of relevant and irrelevant stimulus attributes. Upon a nonreversal shift, Ss who were rapid solvers on the original task remained rapid solvers on the shift task. When a 40/40 overlearning criterion was imposed, those Ss who solved rapidly exhibited a backward memory deficit for relevant attributes and had difficulty with the shift task, whereas those who solved slowly exhibited a lengthened backward span and solved the shift task rapidly. There was a strong overlearning effect, but it was limited entirely to those Ss who solved the original task slowly.

222. Martin, P. R. & Fernberger, S. W. Improvement in memory span. American Journal of Psychology, 1929, 41, 91-94.

223. Mayzner, M. S., Abrevaya, E. L., Frey, R. E., Kaufman, H. G., & Schoenberg, K. M. Short-term memory in vision: A partial replication of the Averbach and Coriell study. Psychonomic Science, 1964, 1, 225-226.

A partial replication of the Averbach and Coriell study on short-term memory in vision was carried out employing six Ss, with a stimulus array consisting of a 2 x 6 matrix of letters. Three delay intervals of 50, 100, and 150 ms. between letter matrix and bar marker were employed. The results failed to confirm the findings of Averbach and Coriell and showed that delay interval over the range examined had no effect on recognition accuracy.

224. Mayzner, M. S., Adler, S., Cohen, A., & Schoenberg, K. M. A study of the effects of irrelevant information on short-term retention of relevant information. The Journal of Psychology, 1965, 61, 257-262.

The present study, in a series of five experiments employing 200 Ss, examined the effects of irrelevant information on the short-term retention of relevant information. The basic task involved presenting to S a vertical array of either nine digits, nine high-frequency consonants, or nine low-frequency consonants alone, or embedded in increasingly larger matrices of irrelevant digits or high- or low-frequency consonants, and then measuring recall of the relevant items as a function of the number and kind of irrelevant items. The results clearly showed that for all combinations of relevant-irrelevant matrices (i. e., numbers-numbers, numbers-letters, letters-numbers, letters-letters, etc.) no systematic or significant decrements or increments in performance were found, and it was concluded that S is able to attend exclusively to the relevant stimuli.

225. Mayzner, M. S. & Gabriel, R. F. Information "chunking" and short-term retention. The Journal of Psychology, 1963, 56, 161-164.

The present study was designed to examine the effects of information organization or "chunking" on short-term retention. Five different groups of 10 Ss each received the same set of 12 digits for a period of six seconds, but each group received the 12 digits in a different organizational array, i. e., 12 lines (1 digit per line), six lines (two digits per line), etc. The results showed a systematic increase in retention from 12 lines to two lines and a "chunking" model was employed to account for these effects of stimulus organization on retention.

226. Mayzner, M. S. & Gabriel, R. F. Short-term retention of paired-associate material. The Journal of Psychology, 1964, 58, 3-7.

The present study was designed to examine the effects of list length and stimulus familiarity on the short-term retention of paired-associate material. A 2×4 analysis-of-variance design was employed with four levels of list length (three, four, five, and six stimulus-response pairs) and two levels of stimulus familiarity (high and low). The results indicated that both variables had negligible effects, and it was concluded that storage capacity for paired-associated material is very poor.

227. Mayzner, M. A. & Gabriel, R. F. Immediate recall for digram letter matrices. The Journal of Psychology, 1964, 58, 9-15.

The present study was designed to examine the effects of digram frequencies on short-term retention. Ss were presented with a 4×4 display matrix, with each of the 16 cells containing a two-letter pair or digram, and after a period of study were asked for their immediate recall of the matrix. A 2×4 analysis of variance design was employed with four levels of exposure time (15, 30, 60, and 120 seconds) and two levels of digram frequency (high and low). The results showed a systematic increase in recall scores with increasing exposure time for both levels of digram frequency and superior recall of high frequency digrams over low frequency digrams for each level of exposure time. It was recommended that high frequency digrams be employed whenever possible in the design of man-machine displays employing an "alpha"-type code.

228. Mayzner, M. S. & Gabriel, R. F. The effect of spatial organization of the stimulus on short-term retention. The Journal of Psychology, 1964, 58, 17-21.

The present study was designed to examine the effects of spatial organization of the stimulus on short-term retention. Three different groups of 30 Ss each received the same set of 16 high frequency digrams arranged in a 2×8 , an 8×2 , and a circular array for a period of 120 seconds, and then were asked for their immediate recall. The results showed recall to be best for the 2×8 array, next for the circular array, and poorest for the 8×2 array; however, the differences fell just short of significance at the .05 level. It was concluded that these results, taken together with the results from three other studies, do indicate that the spatial organization of the stimulus can significantly affect short-term retention.

229. Mayzner, M. S. & Schoenberg, K. M. Single-letter and digram frequency effects in immediate serial recall. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 397-400.

This study examined the immediate serial recall of letter strings as a function of the single-letter and sequential digram frequencies of the string. Three types of letter strings were constructed, high-frequency digrams (HH), high-frequency consonants combined with low-frequency digrams (HL), and low-frequency consonants combined with low-frequency digrams (LL). Twenty-four Ss received six instances of each type of string and then were asked for their immediate serial recall after each string. The results, predicted on the basis of the "spew hypothesis" of Underwood and Schulz, were confirmed and showed recall to be best for the HH strings, intermediate for the HL strings, and poorest for the LL strings. Analysis of the error data provided further support for the "spew hypothesis," and it was suggested that future investigations of the immediate serial recall of letter strings would need to account for both single-letter as well as digram frequency.

230. Mayzner, M. S. & Schoenberg, K. M. Short-term retention and presentation rate. Psychonomic Science, 1965, 2, 111-112.

Four groups of 30 Ss each were presented with lists of numbers 18 digits in length on a memory drum, one digit exposed at a time, at four different presentation rates, 4 sec. per digit, 2 sec. per digit, 1 sec. per digit, and .50 sec. per digit. The 4 sec. rate was presented for 1 cycle, the 2 sec. rate for 2 cycles, the 1 sec. rate for 4 cycles, and the .50 sec. rate for 8 cycles, holding total display time constant (72 sec.) for all four conditions. Short-term retention decreased as presentation rate increased, even with total display time held constant.

231. Mayzner, M. S. & Schoenberg, K. M. A further study of short-term retention and presentation rate. Psychonomic Science, 1965, 3, 159-160.

Six groups of 10 Ss each were tested in a $3 \times 2 \times 4$ mixed analysis of variance design, in which the effects of 3 variables, namely, list length (10, 14, and 18 digits), number of cycles (single and multi-cycle), and presentation rate (4, 2, 1, and .5 sec. per digit), on the short-term retention of a string of digits were examined. The results clearly showed that all 3 variables produced systematic effects on short-term retention and it was concluded that a trade off between number of cycles and presentation rate is possible, if total display time is held constant, thus supporting the previous work of Bugelski and Murdock in this area.

232. Mayzner, M. S. & Schoenberg, K. M. Short-term storage and retrieval of paired-associate material. The Journal of Psychology, 1955, 59, 113-123.

The present study, consisting of two experiments, was designed to examine the effects of list length and display time on the short-term retention of paired-associate material. In Experiment I, with 90 Ss, a three-by-three-by-five mixed analysis-of-variance design was used with three levels of list length (five, seven, and nine city-temperature pairs), three levels of display time (15, 30, and 60 seconds), and five trials per S. In Experiment II, with 20 Ss, four of the nine conditions involved in Experiment I were tested each week for 10 weeks, with 20 trials per week. The overall results indicate significant effects on storage-and-retrieval capacity as a function of list length, display time, and extended periods of practice.

233. Mayzner, M. S. & Tresselt, M. E. The ranking of letter pairs and single letters to match digram and single-letter frequency counts. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 203-207.

The present study asked if Ss can correctly rank the frequency with which digrams and single letters occur in the language and do this as a function of word length and letter-position variables. The results indicated that Ss can do so successfully. It was suggested that such digram and single-letter frequencies are "stored" by Ss as a frequency-response hierarchy.

234. Mayzner, M. S. & Tresselt, M. E. Tables of single-letter and digram frequency counts for various word-length and letter-position combinations. Psychonomic Monograph Supplements, 1965, 1, 13-32.

This study presents tables, based on a sample of 20,000 English words, which show single-letter and digram frequency counts broken down to account for all word-length and letter-position combinations, for words 3 to 7 letters in length. These tables are similar to those of Pratt and of Underwood and Schulz, but in addition allow for the assessment of frequencies for all word-length and letter-position variations in the word sample. The tables may be employed to provide normative frequency data for studies in verbal learning and retention, anagram problem solving, word recognition thresholds, linguistic analyses, etc.

235. Mayzner, M. S. & Tresselt, M. E. Individual differences in stored digram frequencies and the immediate serial recall of letter and number strings. Psychonomic Science, 1967, 7, 359-360.

This study examined the immediate serial recall of letter and number strings as a joint function of (a) the single-letter and sequential digram frequencies of the letter strings and (b) individual differences in the degree to which Ss already have in "store" information concerning the relative frequency of digrams as they occur in the language. The results clearly showed that high digram storage Ss show superior recall to low digram storage Ss for letter strings that vary both with respect

to their single-letter frequencies and sequential digram frequencies, but that no differences in recall occur between the high and low digram storage Ss for the number strings.

236. Mayzner, M. S. & Tresselt, M. E. Immediate serial recall of mixed letter strings. Psychonomic Science, 1967, 7, 401-402.

This study examined the immediate serial recall of letter strings composed of a mix of high and low frequency consonants, for high and low digram storage Ss. The results clearly showed that high digram storage Ss show superior recall to low digram storage Ss for mixed letter strings and that systematic proactive and retroactive effects on recall performance occur with such mixed letter strings.

237. Mayzner, M. S., Tresselt, M. E., Adler, S., Cohen, A., & Schoenberg, K. M. Short-term retention, presentation rate, and number of display cycles. Psychonomic Science, 1966, 5, 317-318.

Previous work of Bugelski, Mayzner, and Schoenberg, and Murdock has shown that if total display time is held constant, trade offs may be found between number of display cycles (i. e., the number of times a list is repeated before recall is requested) and display presentation rates. The present study extends these earlier findings by showing that for the short-term retention of a string of 20 digits, trade offs may be obtained over the range from 1 display cycle and a presentation rate of 8 sec. per digit to 16 display cycles and a presentation rate of 1/2 sec. per digit. A breakdown does apparently occur with 32 display cycles and a presentation rate of 1/4 sec. per digit, where clear input registration is apparently degraded by the rapidly changing display.

238. Mayzner, M. S., Tresselt, M. E., Adler, S., Cohen, A., & Schoenbert, K. M. Short-term retention of digits: A function of item distribution with respect to time. Psychonomic Science, 1966, 5, 403-404.

In the present study 20 single digits were presented sequentially during a 40 sec. display period and five conditions of input timing distributions were examined, employing a computer-based CRT display system. In one condition the 20 digits were distributed evenly through time at a rate of 2 sec. per digit. In the other four conditions the 20 digits were presented at a rate of 1 sec. per digit and the remaining 20 sec. was distributed in various ways throughout the total 40 sec. display period. The results showed very significant effects as a function of varying the input timing distributions and plots of the serial position curves revealed a highly systematic multi-bowing effect which strongly suggests that input "chunking" is time-locked to input timing distributions.

239. Mayzner, M. S., Tresselt, M. E., Adler, S., & Schoenberg, K. M. Correlations between subject generated letter frequencies and observed frequencies in English. Psychonomic Science, 1964, 1, 295-296.

Five groups of 10 Ss each were asked to randomly generate 1000 single letters, 500 digrams, 334 trigrams, 250 tetragrams, and 200 pentagrams. Correlations between generated single letter frequencies and observed frequencies in English were high, ranging from .70 to .83, and it was concluded that Ss do not operate as random letter generators, but rather reflect quite precisely single letter frequencies as found in the language.

240. Mayzner, M. S., Tresselt, M. E., Adrignold, A. J., & Cohen, A. Further preliminary findings on some effects of very fast sequential input rates on perception. Psychonomic Science, 1967, 7, 281-282.

A previous study, employing a computer-based CRT display system, showed that if the visual system is presented with a string of very fast sequential inputs approximately the first half of these inputs will not be perceived if display order is irregular and display input rate is in the range from approximately 10 to 20 msec. per letter and per interval between letters. In the present study, this phenomena called sequential blanking is examined further and the results suggest certain irregular display orders may also give rise to a spatial displacement of one letter away from another in the sequence, and this phenomena has been called sequential displacement.

241. Mayzner, M. S., Tresselt, M. E., & Cohen, A. Preliminary findings on some effects of very fast sequential input rates on perception. Psychonomic Science, 1966, 6, 513-514.

A study was made of the effects of presenting to the visual system a string of very fast sequential inputs, employing a computer-based CRT display system. The results showed that for either 5 or 10 inputs (i. e., all Xs, random letters, letters forming a word, or small line segments) approximately the first half of these sequentially presented inputs were not perceived, if display order was irregular and display input rate was fixed at certain values between clear simultaneity and clear sequentially.

242. Mayzner, M. S., Tresselt, M. E., & Helfer, M. S. A research strategy for studying certain effects of very fast sequential input rates on the visual system. Psychonomic Monograph Supplements, 1967, 2 (5, Whole No. 21), 73-81.

The present paper describes an experimental computer-based CRT display facility, a computer display program, and a research strategy for studying how the visual system processes a train of stimuli or inputs when (1) these inputs arrive sequentially in time, (2) occur at different locations in space, and (3) are displayed at varying input rates, from very fast (i. e., 100 msec per input) to relatively slow (i. e., 500 msec). Seven stimulus parameters believed critical to visual information

processing mechanisms with sequential inputs are identified--namely, input display order, input display rate, number of inputs, content of inputs, input size, input intensity, and input spacing--and future research developments are briefly outlined.

243. Mayzner, M. S., Tresselt, M. E., & Wolin, B. R. Tables of trigram frequency counts for various word-length and letter-position combinations. Psychonomic Monograph Supplements, 1965, 1, 33-78.

Trigram frequency counts are given for all word-length and letter-position combinations for words three to seven letters in length on a sample of 20,000 English words.

244. Mayzner, M. S., Tresselt, M. E., & Wolin, B. R. Tables of tetragram frequency counts for various word-length and letter-position combination. Psychonomic Monograph Supplements, 1965, 1, 79-143.

Tetragram frequency counts are given for all word-length and letter-position combinations for words four to seven letters in length on a sample of 20,000 English words.

245. Mayzner, M. S., Tresselt, M. E., & Wolin, B. R. Tables of pentagram frequency counts for various word-length and letter-position combinations. Psychonomic Monograph Supplements, 1965, 1, 145-185.

Pentagram frequency counts are given for all word-length and letter-position combinations for words five to seven letters in length on a sample of 20,000 English words.

246. McNulty, J. A. An analysis of recall and recognition processes in verbal learning. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 430-436.

The purpose of this experiment was to demonstrate that the superiority of recognition over recall is due in part to the use of the whole item as the basic unit of measurement. About some items, Ss learn less than the whole item, and it is on the basis of this partial learning that items which cannot be recalled are, nevertheless, easily recognized.

Lists of items of three different orders of approximation to English were given to Ss to learn. Retention was measured after each learning trial either by recall, standard recognition, or restricted recognition. The standard recognition test contained the original items plus an equal number of other items from the same order of approximation. In an effort to restrict the potential effectiveness of partial learning, the other recognition test contained incorrect alternatives differing from the original items in only one letter.

Results of the experiment showed that when opportunities for partial learning to be of use in recognition were restricted, much of the difference between recall and recognition disappeared. Order of approximation and its interaction with method of measurement also had statistically significant effects.

247. McNulty, J. A. Short-term retention as a function of method of measurement, recording time, and meaningfulness of the material. Canadian Journal of Psychology, 1965, 19 (3), 188-196.

Ss were given a list of dissyllables containing high, medium, and low meaningful items to learn for four trials. After each trial retention was measured by one of the following methods: (1) serial anticipation, (2) reconstruction, (3) unaided recall, or (4) recognition. Also varied was the time that Ss were allowed to record their retention, because this time variable has typically been uncontrolled in similar experiments. Results of the experiment showed that both method of measurement and time allowed to record retention were significant variables. The interaction between meaningfulness of the material and method of measurement was also significant. Low meaningful material appeared to be harder to recall, reconstruct, or serially anticipate than highly meaningful material, but was easier to recognize. This finding was attributed to a von Restorff contrast effect.

248. McNulty, J. A. The effects of "instructions to mediate" upon paired-associate learning. Psychonomic Science, 1966, 4, 61-62.

Ss were given two paired-associate lists to learn at either the first, third, or text orders of approximation to English. One-third of Ss at each order received "mediating" instructions between the two lists, another third received "motivating" instructions, and the remainder simply rested. Mediating instructions facilitated second list learning at higher orders of approximation, but the effect was only obtained with relatively unmotivated Ss. When highly motivated Ss were used, there was little difference among the three groups.

249. McNulty, J. A. The measurement of "adopted chunks" in free recall learning. Psychonomic Science, 1966, 4, 71-72.

Ss were given one learning trial on each of three lists presented in counterbalanced order. One of the lists contained items of the first order of approximation to English; another contained third order items; and the third consisted of text order items. After each trial Ss recalled as many items or parts of items as they could. The number of whole items remembered was a direct function of approximation to English. When "adopted chunks" were measured, there were no differences among lists in the number of chunks remembered. Between seven and eight chunks of information were recalled at all orders of approximation.

250. McNulty, J. A. A partial learning model of recognition memory. Canadian Journal of Psychology, 1966, 20(3), 302-315.

251. McNulty, J. A. & Caird, W. Memory loss with age: Retrieval or storage? Psychological Reports, 1966, 19, 229-230.

The suggestion that memory loss as a result of the aging process is due to a loss in the ability to retrieve memories from storage is challenged. An alternative hypothesis, that of a defect in the storage system itself, is proposed. Some empirical evidence to support this view is presented.

252. McReynolds, P. & Acker, M. Serial learning under conditions of rapid presentation of stimuli. American Journal of Psychology, 1959, 72, 589-592.

A technique was developed for investigating the learning of nonsense-syllables under conditions of very rapid presentation of the stimulus-materials. With the ratio between exposure and inter-exposure interval constant, and rate of presentation varying from 2-12 syllables per second, it was found that the amount learned increases logarithmically as the rate of presentation decreases.

253. Melton, A. W. Implication of short-term memory for a general theory of memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 1-21.

254. Melton, A. W., Sameroff, A., & Schwat, E. D. Short-term recognition memory. Paper presented at the Fourth Annual Meeting of the Psychonomic Society, August 31, 1963.

255. Metzger, R., Simon, S., & Ditrichs, R. Effects of retention interval activity on short-term memory in retardates. Psychonomic Science, 1965, 3, 55-56.

Seventy retarded Ss showed reductions in the short-term retention of single verbal items to 73% correct recall in 16 seconds under conditions where words different from the stimulus word filled the retention interval. Under retention interval conditions of no instructed activity, instructed rehearsal, and music listening, negligible declines in recall were observed.

256. Miller, G. A. The magical number seven, plus or minus two: Some limits on our capacity for processing information. Psychological Review, 1956, 63, 81-97.

257. Monty, R. A. Spatial encoding strategies in sequential short-term memory. Journal of Experimental Psychology, 1968, 77, 506-508.

Keeping-track performance was examined as a function of cues designed to control the spatial encoding strategies adopted by the Ss. Spatial organization of the material to be remembered significantly affected short-term retention and interacted with the characteristics of the type of stimulus materials employed, demonstrating that visual encoding can play an important role in short-term memory.

258. Monty, R. A., Fisher, D. F., & Karsh, R. Stimulus characteristics and spatial encoding in sequential short-term memory. Journal of Psychology, 1967, 65, 109-116.

Performance of the keeping-track task described by Monty, Taub, and Laughery (5) was examined as a function of the class of stimuli employed. It was found that a stimulus class possessing a natural or built-in order led to better performance than did a stimulus class lacking such order. It was suggested that the differences stem from the speed with which Ss complete encoding of the information to be remembered rather than from the time available for rehearsal between successive stimuli.

259. Monty, R. A., Karsh, R., & Taub, H. A. Keeping track of sequential events: Irrelevant information and paced rehearsal. Perceptual and Motor Skills, 1967, 24, 99-103.

The effects of irrelevant information on Ss' ability to keep track of a changing situation mentally were examined. It appears that, when relevant stimuli are presented at an irregular rate of presentation, irrelevant stimuli interspersed with the relevant stimuli may enable Ss to pace rehearsal of the current state of the changing situation in a fashion that reduces the interference effects of the irregular rate of presentation.

260. Monty, R. A., Karsh, R., & Taub, H. A. Pacing of rehearsal in sequential short-term memory. Journal of Experimental Psychology, 1967, 74, 300-302.

The Ss were required to keep track mentally of the number of occurrences of each of four different symbols presented sequentially. It was found that a light introduced into the sequence just prior to the presentation of each successive symbol tended to enhance performance. It was suggested that the light served to cue Ss to complete rehearsal of the current state of the information in preparation for the next stimulus in the sequence.

261. Monty, R. A., Taub, H. A., & Laughery, K. R. Keeping track of sequential events: Effects of rate, categories, and trial length. Journal of Experimental Psychology, 1965, 69, 224-229.

Subjects were required to count the number of occurrences of each of several different symbols (categories) presented sequentially as a function of the number of categories (2, 3, or 4), the total number of items (8, 12, 16, or 20), and the rate of presentation (one item every 0.6, 1.0, 2.0, 3.0, and 4.0 seconds). In general, the greater the number of categories, the greater the total number of items, or the faster the rate of presentation, the poorer the performance. Of primary importance, however, is the complex interaction between these variables. The observed results are explained primarily on the basis that both presentation rate and number of categories affect the time available for rehearsal of the information while trial length results in an accumulation of errors with time.

262. Montague, W. E. & Hillix, W. A. Intertrial interval and proactive interference in short-term motor memory. Canadian Journal of Psychology, 1968, 22, 73-78.

The experiment questioned whether proactive interference (PI) occurred in STM for linear motor responses. Ss had 7 trials, each with a different response length. Each trial consisted of 4 training repetitions (Rs) after each of which recall was tested (T), a retention interval, and a recall test (T_r). Intertrial intervals (ITIs) of 5, 20, and 80 seconds and retention intervals of 5 and 80 seconds were between-groups variables. Mean absolute error on T_r was reliably greater after the longer retention interval but was not affected by ITI. T_r error provided no evidence for PI. A PI effect was found on the first training T, but this effect disappeared after 4 Rs. The results suggest that motor memory may be a rapidly decaying trace which is available to interact with the learning of a subsequent response for only a brief time. The underlying mechanism may differ from that of verbal STM although additional evidence attesting to this difference is necessary.

263. Moray, N. Broadbent's filter theory: Postulate H and the problem of switching time. Quarterly Journal of Psychology, 1960, 12, 214-221.

Groups of digits were presented binaurally and dichotically to subjects who were asked to recall them. Different rates and patterns of presentation were used, the design being based on that of Broadbent (1954). Broadbent's findings in this field were confirmed. If subjects are presented with simultaneous pairs of digits at a rate of 2 pairs per second dichotically, they cannot recall them if they are asked to alternate between the ears. If however, the presentation is staggered, so that although the rate is constant the signals do not overlap, subjects can recall alternately from the two ears. It is suggested that these findings are better interpreted as an interference effect, not a rate effect. Criticism is offered of similar designs to measure "switching rate." Criticism is also offered of Broadbent's estimate of "perception time" in such experiments. An analysis of the quantity and type of

errors made by subjects is given, which suggests that Broadbent's theory of a short term store on the peripheral side of a selective filter is in need of revision.

264. Moray, N. Where is capacity limited? A survey and a model. Acta Psychologica, 1967, 27, 84-92.

A model is presented for the limitations of processing information by the human operator which proposes that he acts not as a limited capacity channel with fixed capacity, but as a limited capacity processor. The total capacity of the brain can be allocated to the separate aspects of the tasks, such as reception, recoding, emission, storing, etc. Hence from moment to moment the size of the 'channel' in the Shannon sense will appear to vary. In particular parallel processing is possible where the total capacity is not exceeded, and where there is high compatibility. Experimental evidence in support of the model is presented.

265. Moray, N. & Barnett, T. Stimulus presentation and methods of scoring in short-term memory experiments. Acta Psychologica, 1965, 24, 253-263.

(1) The transmission through channels distinguished by the physical characteristics of a voice has limitations similar to those due to spatial separation.

(2) By examining different kinds of error score, omissions, order errors, commissions, etc., we can study mechanisms more clearly.

(3) By altering presentation rate, transmission strategy and the size of stimulus ensemble, we can manipulate these different mechanisms to some degree independently one of another.

(4) An important example of this last factor is the one of stimuli where the whole ensemble is present on each trial, so that there is a very straight-forward sense no ambiguity about content but only about order.

266. Moray, N., Bates, A., & Barnett, T. Experiments on the four-eared man. Journal of the Acoustical Society of America, 1965, 38, 196-201.

Subjects were required to listen to messages consisting of 1, 2, 3, or 4 letters of the alphabet over each of 1, 2, 3, or 4 channels. It was found that increasing the number of channels above 2 had a markedly deleterious effect upon recall of the messages, 2 letters over each of four channels being less well recalled than 4 letters over each of two channels. In a second experiment, it was found that, providing only one channel was required in recall, and this one was indicated by a light immediately after the stimuli had been presented, the decrement could be largely offset and the total number of signals stored held constant at about 8 regardless of how many channels were used. However if the letters had to be recalled in exactly the correct order in which they arrived, performance dropped to almost zero. The results are discussed in terms of the channel capacity of the nervous system and in relation to corresponding findings in other sense modalities.

267. Moray, N. & Jordan, A. Practice and compatibility in 2-channel short-term memory. Psychonomic Science, 1966, 4(12), 427-428.

Eleven Ss were required to listen to three pairs of digits presented dichotically. The member of each pair arrived simultaneously at opposite ears. They were asked to recall them either vocally, alternating between the ears, or manually on a keyboard which allowed them to respond to both ears at once. Contrary to Broadbent's earlier findings, very high levels of recall can be achieved in both conditions when the presentation rate is as high as 2 signals/ear/second.

268. Moray, N. & Reid, A. J. Two channel immediate memory span. Psychonomic Science, 1967, 8, 249-250.

Lists of digits were presented dichotically to Ss who were required to recall them by typing those received by the left ear with the left hand and those received by the right ear with the right hand. The immediate memory span whether measured by the performance on either or on both of the channels combined was substantially inferior to performance where only one list was heard and the S typed the response with one hand.

269. Morin, R. E., DeRosa, D. V., & Stultz, V. Recognition memory and reaction time. Acta Psychologica, 1967, 27, 298-305.

Sternberg has proposed that recognition memory involves a serial and exhaustive search process. It is presumed that a representation of the test stimulus is successively compared to representations of every item in a to-be-remembered set. One prediction from the theory is that reaction time to a stimulus probe should not be a function of the serial position of the probed item within the set to be remembered. This prediction was tested in a recognition memory task. The prediction was not confirmed in that RT was markedly influenced by the serial position of items to be recognized. Especially significant was a large recency effect evidenced by most rapid recognition of the most recently presented item. Alternative interpretations of the data are considered.

270. Morin, R. E., DeRosa, D. V., & Ulm, R. Short-term recognition memory for spatially isolated items. Psychonomic Science, 1967, 9(12), 617-618.

With from three to six digits presented prior to a recognition probe, the only evidence for a von Restorff effect existed in faster reaction times to probes of the isolated stimulus with sets of size 6.

271. Morin, R. E. & Konick, A. Short-term memory and reaction time: Keeping track of several variables. Psychonomic Science, 1964, 1, 325-326.

Reaction time (RT) and response accuracy depend on the remoteness, in terms of time and number of intervening trials, of a previous response which serves as the stimulus for a present response.

272. Morrissette, J. O., Crannell, C. W., & Switzer, S. A. Group performance under various conditions of work load and informational redundancy. Journal of General Psychology, 1964, 71, 337-347.
273. Moss, S. M., Hearns, J. F., & Soward, J. B. Factors affecting information processing in short-term memory. Report No. 2, Engineering Psychology Branch, Office of Naval Research, Department of the Navy, Washington, D. C., December 1966.

Three experiments were conducted to investigate several of the variables that affect information processing in short-term memory as reflected by the strategies used by Ss in a visual search task. The first study investigated differences in strategy as a function of method of payoff. The second study was concerned with changes in strategy when Ss shifted from one incentive ratio to another. The third study was concerned with differences in strategy when Ss were confronted with different work loads. Two general conclusions have emerged from these investigations. First, Ss strategy for optimal information processing in this task is determined by his method of payoff and his work load (Study 1 and Study 2). Second, the degree to which a strategy can be successfully implemented is limited by the interference effects of differential target value and value ratio (Study 1 and Study 2).

274. Moss, S. M., Soward, J. B., & Hearns, J. F. The effects of load variability in short-term memory task. Perception & Psychophysics, 1968, 3, 445-448.

Six groups of Ss viewed briefly exposed arrays of letters, half designated high-valued and half low-valued. Immediately after each exposure Ss wrote down as many of the stimuli as they could remember. For three groups, the number of letters in each exposure was constant from trial to trial; for the remaining three groups, the number of letters in each exposure varied from trial to trial. This tested the hypothesis that load variability influences the development of an efficient response strategy which, in turn, affects the processing of information stored in short-term memory. The data supported this hypothesis. Performance was superior under the constant load condition due to the ability of these Ss to correctly report both high- and low-valued letters. Poor performance was observed under the variable load condition because of a decrease in the number of low valued letters correctly reported.

275. Murdock, B. B., Jr. The immediate retention of unrelated words. Journal of Experimental Psychology, 1960, 60, 222-234.

A number of experiments are reported which investigated the immediate retention of unrelated words. Some studied retention following a single presentation; others studied the changes in retention that occurred with repeated presentations. The latter experiments were in effect studies of free-recall verbal learning. The method of free-recall verbal learning was selected for investigation because, it was found, the results of individual Ss learning single lists could adequately be described by an exponential function.

For the experiments on free-recall verbal learning a standard procedure and a standard method of fitting the exponential were used; normative data and data on reliability were presented. It was shown that there was no learning-how-to-learn or warm-up effect. Also, there was no difference between visual and auditory presentation or between individual and group testing. Learning was found to be a linear function of log frequency of usage.

The two experimental variables most intensively investigated were length of list and presentation time per item. The number of items retained after one presentation was a linear function of the total time required for presentation of the list, where the total time was a product of the length of list and the presentation time per item. Given this linear relationship and the exponential function for free-recall verbal learning it was possible to predict the learning of a list with a fair degree of accuracy given its length and presentation time.

276. Murdock, B. B., Jr. The retention of individual items. Journal of Experimental Psychology, 1961, 62, 618-625.

Three experiments were conducted on the short-term retention of individual items. Experiment I confirmed the findings of Peterson and Peterson (1959) and suggested that the number of items or "chunks" of information in the to-be-remembered stimulus item may be a significant variable in short-term retention. Experiment II demonstrated a significant proactive inhibition effect and suggested that the effect may be a U shaped function of number of preceding items. Experiment III showed that the rate of interpolated activity did not have a significant effect on short-term retention. The implications for a decay theory and an interference theory of forgetting were briefly discussed.

277. Murdock, B. B., Jr. The serial position effect of free recall. Journal of Experimental Psychology, 1962, 64, 482-488.

This experiment was a study of the serial position effect of free recall. Curves were obtained for 10-2, 20-1, 15-2, 30-1, 20-2, and 40-1 lists, where the first number indicates list length and the second number indicates presentation time per word. On the basis of the available evidence it was concluded that, under the conditions of the present experiment, the serial position curve is characterized by a steep, possible exponential, primacy effect extending over the first three or four words in the list, an S shaped recency effect extending over the last eight words in the list, and a horizontal asymptote spanning the primacy and recency effect. Finally, it was suggested that the shape of the curve may well result from proactive and retroactive inhibition effects occurring within the list itself.

278. Murdock, B. B., Jr. Short-term memory and paired-associate learning. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 320-328.

This study deals with the relationship between STM and PA learning. The first three experiments were an attempt to determine if traditional variables of PA learning had the expected effect on STM for individual pairs. The general procedure was such that a list of pairs composed of common English words paired at random was presented once with a presentation time of 2 seconds per pair; then, one of the pairs was tested for recall.

In Exp. I lists were two, three, four, or five pairs long. In Exp. II presentation time was 1, 2, or 3 seconds per pair. In Exp. III one, two, or three presentations of each list preceded the recall test. Results suggested that the retention curve leveled out after approximately two subsequent pairs at a value which increased with presentation time, number of presentations, and, possibly, shorter lists.

Experiment IV was essentially the first trial of a PA learning task; all pairs were tested for recall and lists were 8, 16, 24, or 32 pairs long. As predicted, number of words recalled increased with list length. Also, during the first block of eight recalls, recall probability for the 8 pair list was higher than for the 16-, 24-, and 32-pair lists; the latter three lengths did not differ.

In general the results lent support to the notion that there might be marked intratrial learning and forgetting of individual pairs during PA learning, that some of the phenomena of PA learning might be predictable from studies of STM, and the PA "learning" might basically be increased resistance to intertrial forgetting.

279. Murdock, B. B., Jr. Interpolated recall in short-term memory. Journal of Experimental Psychology, 1963, 66, 525-532.

Three experiments were conducted to determine the effect of interpolated recall on short-term memory for individual paired associates. Lists of 6 pairs were presented once, then 3 pairs (Experiment I) or all 6 pairs (Experiment II) were tested for recall. Recall tests were self-paced in Experiments I and II but paced at either a fast or slow rate in Experiment III. The results showed that recall deteriorated as number of interpolated recalls increased, but the effect was limited to 1 or 2 interpolations for pairs near the end of the list. Thereafter, the retention curve appeared to stay level at a value considerably greater than 0 over the range of retention intervals studied. The results of these and other experiments suggest that the interference generated by interpolated recall may be a rather common effect in short-term memory.

280. Murdock, B. B., Jr. Proactive inhibition in short-term memory. Journal of Experimental Psychology, 1964, 68, 184-189.

To study PI effects in short-term memory for paired associates, 60 Ss were tested on 6 lists of 6 pairs each. The A-B pairs consisted of common English words paired at random. After each list had been presented once, Ss were tested for retention of 1 of the 6 pairs by presenting A as the cue for recall of B. Serial position of the critical pair was counterbalanced across stage of practice. While there were changes in the serial-position curve as a function of stage of practice, when summed over all retention intervals performance did not deteriorate with practice. The results do not readily fit a PI interpretation of forgetting; instead, Broadbent's hypothesis of a limited capacity system seems more applicable.

281. Murdock, B. B., Jr. Associative symmetry and dichotic presentation. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 222-226.

Dichotic presentation was used to provide a further test of associative symmetry in STM. The two members of each pair were presented simultaneously, one to each ear, and S was required to verbalize each pair so that it could be tagged as "forward" or "backward." Each list consisted of six pairs; one pair per list was tested, and over the entire 156 lists each serial position was tested equally often. There were 20 Ss, each tested (individually) on two separate sessions. The two tapes were counterbalanced over sessions; speakers and channels were also counterbalanced.

In general the results supported associative symmetry; accuracy of recall was equally good in either direction (i.e., left-right and right-left); backward associations were, if anything, slightly stronger than forward associations; and intra-list intrusions were equally likely to come from the same input channel, but significantly more likely to be in the same relative output order as the correct response. A supplementary experiment with different tapes yielded very similar results, and at the same time reinforced the one exceptional finding of the first experiment; namely, for the penultimate pair in the list, forward recall was, in fact, better than backward recall.

This study extends previous findings in that it shows associative symmetry to hold under conditions of simultaneous input and sequential processing. The one case of lack of symmetry may be attributable to differences in availability as found in free recall.

282. Murdock, B. B., Jr. A test of the "limited capacity" hypothesis. Journal of Experimental Psychology, 1965, 69, 237-240.

If as suggested recently an individual does have a limited capacity for recall in STM, then simultaneous variation in number of presentations and rate of presentation (with total presentation time constant) should result in equal recall. To test this hypothesis, Ss were given 1 presentation of 6 pairs at a rate of 4 sec/pair,

2 presentations at 2 sec/pair, or 4 presentations at 1 sec/pair, then tested for recall of the B member of 1 of the 6 A-B pairs. Recall probabilities for the 1st and 3rd condition were indistinguishable, while the 2nd condition was superior only at the shorter retention intervals. Considering this and other evidence, it was concluded that the limited capacity hypothesis may be a useful 1st approximation.

283. Murdock, B. B., Jr. Signal-detection theory and short-term memory. Journal of Experimental Psychology, 1965, 70, 443-447.

This study attempted to apply signal-detection theory to short-term memory of testing the high-threshold concept of associative strength. On each trial a list of 6 A-B pairs was presented once, then 1 of these 6 pairs was tested for recognition. On the recognition test either A-B (a proper pair) or A-X (an improper pair) was presented; S had to make a binary (yes-no) decision plus a confidence rating. From these data ROC curves were plotted, and they resembled the curvilinear functions of signal-detection theory more than the linear function required by the high-threshold concept. These results call into question the use of a high-threshold concept to explain findings from studies of 1-trial learning.

284. Murdock, B. B., Jr. Effects of a subsidiary task on short-term memory. British Journal of Psychology, 1965, 56, 413-419.

If there is a limited-capacity mechanism in STM then introducing a concurrent subsidiary task should adversely affect recall. Two experiments on free recall were conducted with card sorting as the subsidiary task. In the first experiment subjects dealt cards into one pile, into two piles by colour, or into four piles by suit while lists of common English words were being read. Subjects sorted cards only during presentation of the lists. As the subsidiary task became more demanding the number of words correctly recalled decreased. In the second experiment sorting by suit was combined with free recall, and the payoffs (relative importance of the two tasks) were varied. Performance on both the recall and the card sorting tasks deteriorated as the other task was stressed. Differences in recall could not easily be attributed to differences in original learning, and the results suggested that the subsidiary task interfered with rehearsal and/or decreased total presentation time for free recall.

285. Murdock, B. B., Jr. Visual and auditory stores in short-term memory. The Quarterly Journal of Experimental Psychology, 1966, 18, 206-211.

If retrieval in short-term memory can be either from a pre-perceptual sensory store or from a post-perceptual memory then recall should vary as a function of input into sensory store. To test this possibility two experiments with paired associates compared visual and auditory presentation under conditions as comparable as possible. In both experiments modality interacted with retention interval; more recency with auditory but, in Experiment 1, more primacy with visual. The interaction was taken as support for the hypothesis. An alternative hypothesis (that storage is post-perceptual but not a-historical) was discussed and weak negative evidence presented.

286. Murdock, B. B., Jr. The criterion problem in short-term memory. Journal of Experimental Psychology, 1966, 72, 317-324.

According to signal-detection theory the response is a function of both sensitivity and the criterion; this experiment tested for criterion shifts in short-term memory (STM). Each list consisted of 5 A-B paired associates followed by a probe (A or B) for 1 of the pairs. Four Ss were tested intensively, and recall was supplemented with confidence ratings and latency measures. Analysis of the results showed that the strength of the evoked response (as measured by d') was invariant over serial position but the criterion (as measured by δ) became stricter as retention interval increased. Thus the predicted changes did occur; these findings raise doubts about conventional error analyses in studies of human verbal learning and suggest caution in extrapolating from probability measures to strength measures.

287. Murdock, B. B., Jr. Distractor and probe techniques in short-term memory. Canadian Journal of Psychology, 1967, 21, 25-36.

Two experiments were conducted to determine if, as commonly believed, there is a marked difference in short-term memory as a function of whether the retention interval is filled with unrelated non-learning materials (distractor technique) or with categorically related learning materials (probe technique). The first experiment was a replication of a previous trigram study, and inter-experiment comparisons suggested the same basic retention function for distractor and probe techniques. The second experiment attempted to show that both types of retention-interval activity had comparable effects in a probe type of paired-associate task. It was suggested that rate constants might differ but the function itself would not; and the amount of material to be remembered appears more critical than the type of interpolated activity.

288. Murdock, B. B., Jr. Auditory and visual stores in short-term memory. Acta Psychologica, 1967, 27, 316-324.

Three experiments were conducted to investigate the modality effect in short-term memory. The first experiment used paired associates, and found larger differences between auditory and visual presentation when verbalization at the time of presentation was eliminated. The second and third experiments used serial lists; the modality effect was obtained over the full retention period and seemed most pronounced when both the probe and the correct response (i.e., the following word) were auditory.

The data support the previous contention that, in short-term memory, retrieval can be from a preperceptual sensory store. Modality differences can be very large, and they seem to argue against the notion that the function of the list presentation is merely to tag words for later retrieval. In the mixed-mode experiment, switching of attention may be involved, but it alone does not seem adequate to explain the results obtained.

289. Murdock, B. B., Jr. Recent developments in short-term memory. The British Journal of Psychology, 1967, 58, 421-434.

This paper reviews some recent developments in the area of short-term memory. The methodological innovations include the distractor technique and the probe technique. The main empirical phenomena discussed are recency effects, input and output interference, the length-difficulty relationship, inter-item interference effects, the distribution of practice interaction, associative symmetry, modality effect, acoustic confusions, and transpositions. A "modal model" is presented which attempts to synthesize some recent theoretical conceptions; the components include sensory, short-term and long-term stores with three different forgetting mechanisms (decay, displacement and interference, respectively).

290. Murdock, B. B., Jr. The effects of noise and delayed auditory feedback on short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 737-743.

Several recent experiments have suggested that, in STM, retrieval can be either from a preperceptual sensory store or a postperceptual memory. As a further test, an experimental distinction was attempted: in Exp. I white noise was used to degrade the sensory input; in Exp. II DAF was used to degrade processing. It was found that white noise adversely affected recall given veridical perception at the time of presentation, but the effects of DAF were conspicuous by their absence. It was concluded that these findings gave further support to the hypothesis that retrieval can be from a preperceptual sensory store.

291. Murdock, B. B., Jr. Theoretical note: A fixed-point model for short-term memory. Journal of Mathematical Psychology, 1967, 4, 501-506.

Most current models for short-term memory assume at least two separate storage systems. A unitary model for paired associates that seems capable of accounting for at least the gross empirical phenomena is proposed. Transitions both into and out of the recall state are possible, and the fixed point of the transition matrix determines the asymptote of the short-term retention curve. Experimental evidence is presented to document the contention that a steady state is achieved by practiced subjects after a single presentation of a list of paired associates.

292. Murdock, B. B., Jr. Serial order effects in short-term memory. Journal of Experimental Psychology Monograph Supplement, 1968, 76, 1-15.

A series of studies of serial order effects in short-term memory (STM) were performed using a variety of techniques (sequential probe, positioned probe, reverse probe, ordered recall, and cued recall). The most general finding was the conspicuous occurrence of the U-shaped bowed serial position curve. Evidence suggested that the probe technique with a recall-probability measure severely underestimates the magnitude of primacy effects in STM because of (a) criterion changes,

and (b) loss of context effects. The data did not seem consistent with the displacement mechanism currently postulated by some models to account for short-term forgetting; a compression process was suggested instead. The time invariance of paired associates and free recall was not obtained; instead, with longer lists the information per item decreased but the total amount of stored information seemed to stay constant.

293. Murdock, B. B., Jr. & vom Saal, W. Transpositions in short-term memory. Journal of Experimental Psychology, 1967, 74(1), 137-143.

This study attempted to determine whether transpositions occur during storage or during retrieval. A distractor task (Peterson & Peterson technique) was used in which word trigrams were followed by a variable-length retention interval. Words were used to minimize acoustic confusions, and the trigrams were composed of same-category or different-category items (e.g., GRAY BROWN RED vs. EEL SCREW LOUNGE). The same-category trigrams were better retained than the different-category trigrams but also transposed more. In addition, transpositions increased in frequency over the retention intervals used. Conrad has suggested that transpositions do not occur during storage; the results obtained here suggest the opposite conclusion.

294. Murray, D. J. Effects of loudness and presentation-rate on auditory short-term memory. Nature, 1966, 210, 226.

295. Murray, D. J. Intralist interference and rehearsal time in short-term memory. Canadian Journal of Psychology, 1966, 20, 413-426.

Three experiments are reported in which items required for immediate recall were alternated with "interfering" items not required for recall, but demanding overt responses. Presentation rate was also varied. In Experiment I letters were alternated with "interfering" digits: having to calculate the digits mentally led to reduced recall of the letters. In Experiment II "required" letters were repeated, three presentation rates also being used: lists with repetitions were more poorly recalled than lists without repetitions, but in the former condition, the slower the rate, the better was recall. In Experiment III "required" letters were alternated with digits or rhyming letters: letter interference produced poorer recall, but there was also an interaction with presentation rate. An "interfering" letter closely preceding a "required" letter was more likely to replace the latter in recall than was one preceding it at a longer interval. It is agreed that both rehearsal opportunity and response competition determined recall, and that simple versions of decay theory or interference theory are inadequate to cover all these results.

296. Murray, D. J. The role of speech responses in short-term memory. Journal of Psychology, 1967, 21(3), 263-276.

Three experiments are reported in which Ss saw lists of letters for immediate recall, but had to say a neutral sound as they perceived each letter. In Experiment I this technique substantially reduced recall of letters, spoken as capitals as compared with that for normally voiced lists, but no difference between "suppression" and voicing emerged if the letters were pronounced in altered fashion (e.g., BDF pronounced as "buh duh fuh . . ."). In Experiment II, having to say a sound which coincided with the dominant sound of the presented list led to slightly poorer recall than did the saying of non-coincident sounds at presentation. Experiment III showed that the main advantage for recall of articulation consisted in raising the recall particularly of lists of low acoustic similarity, reducing order errors, and raising the recall particularly of the early and middle items of lists (the latter only if articulation was normally intoned as opposed to monotonous). It is concluded that the advantage of articulation at presentation increases as the acoustic similarity of the items decreases. Some general implications concerning STM are drawn from this conclusion.

297. Murray, D. J. Overt versus covert rehearsal in short-term memory. Psychonomic Science, 1967, 7(10), 363-364.

Following two silent rehearsals, lists were better recalled than they were following two voiced rehearsals, but there was no interaction between voicing at presentation and voicing during rehearsal. These results held both for forced-order and semi-free order recall, though in the latter recency-effects were enhanced following unvoiced rehearsal. The findings are discussed with respect to the feasibility of using overt rehearsal as a means of investigating rehearsal-processes in general.

298. Muther, W. S. Erasure or partitioning in short-term memory. Psychonomic Science, 1965, 3, 429-430.

The possibility of erasure or partitioning in short-term memory was studied by instructing Ss to retrieve by free recall only 10 relevant letters embedded in a sequence of 20 visually presented letters. In the precuing condition, irrelevant letters were indicated by a preceding blank, while in the post-cuing condition, irrelevant letters were indicated by a following blank. There was no difference in free recall under pre-cuing and post-cuing conditions, although free recall in both was better than chance. Free recall in a cueless control condition with irrelevant letters removed was better than in either pre- or post-cuing conditions. Analysis of errors suggests that irrelevant items were treated by partitioning or tagging in both cuing conditions, rather than by erasure, because cued-out letters occurred as errors of commission significantly more often than did letters which were not presented.

N

299. Nickerson, R. S. Short-term memory for complex meaningful visual configurations: A demonstration of capacity. Canadian Journal of Psychology, 1965, 19, 155-160.

This experiment concerned an aspect of short-term memory somewhat neglected in the past, namely, the ability to remember, i.e., to recognize, complex meaningful visual configurations. S's task was to inspect an extended sequence of photographs of assorted content and to identify those which were occurring for the second time within the sequence. The probability of recognizing the recurrence of a photo as such was very high even with as many as 200 items intervening between its first and second occurrence.

300. Nickerson, R. S. & Brown, C. R. A stimulus ordering technique for controlled lag recognition memory experiments. Psychological Reports, 1963, 13, 319-322.

A method is presented for constructing sequences with properties which make them useful in ordering stimuli for recognition memory experiments. A main feature of the method is the facility for controlling and efficiently manipulating the number of items occurring between the initial and subsequent occurrences of given items.

301. Norman, D. A. Acquisition and retention in short-term memory. Journal of Experimental Psychology, 1966, 72, 369-381.

Retention in short-term memory was studied by manipulating rates of presentation (from 1 to 10 digits per second), the type of digit presentation (spoken, computer spoken, and visually presented), the type of item (single digits, paired digits, and nonsense sounds), and the type of test (recall and recognition). Performance in short-term memory experiments is attributed to interactions among 3 different processes: acquisition, retention, and decision. Rate of presentation, length of list, type of item, and modality seemed mainly to affect the initial acquisition of items in memory. The rate of forgetting depended mainly upon the number of items presented between the critical item and its test.

302. Norman, D. A. Temporal confusions and limited capacity processors. Acta Psychologica, 1967, 27, 293-297.

Theories of limited channel capacity should have some implications on the temporal properties of information processing. Little experimental evidence on this topic is available. Four types of observations are mentioned:

1. The perception of a sequence of single auditory notes when the notes are drawn from two different samples of frequencies.
2. The perception of very fast presented visual items.
3. The perception of very fast presented auditory items, some items being presented twice in succession.
4. The reversal error in short term memory experiments.

Results of some informal investigations are presented, which demonstrate that resolution of time relations among stimuli depends not simply on temporal factors, but also on stimulus-properties.

303. Norman, D. A. & Wickelgren, W. A. Short-term recognition memory for single digits and pairs of digits. Journal of Experimental Psychology, 1965, 70, 479-489.

The operating characteristic is used to examine the relation between the recognition of a single item and the recognition of a pair of items. 29 Ss listened to a sequence of 5 digits, then copied a sequence of 8 digits, and then were given a test of recognition memory for 1 or 2 digits from the original sequence. The operating characteristic for single digits is a smooth function that is symmetrical about the major diagonal, whereas the curve for pairs is highly asymmetrical. False-recognition rates for test pairs containing 1 digit from the original sequence are only slightly greater than false-recognition rates for completely new pairs. Recognition of a pair does not appear to result from independent recognition of each digit. A mathematical model is developed in which the strength of the memory trace has a continuous distribution which is incremented in a probabilistic fashion upon presentation of an item or pair.

P

304. Pearthree, V., Gorfein, D. S., & Bennett, R. W. Acoustic data and recognition in short-term memory. Psychonomic Science, 1967, 8, 59-60.

A system for selecting alternatives to be used in STM recognition studies is suggested based on the use of acoustic confusions made by Ss on hearing their own pronunciations. The system produces credible multiple choice alternatives with specifiable relative probabilities of being selected. It is also clear from the data that factors other than the acoustic coding of items plays an important role in short-term retention.

305. Peterson, L. R. Associative memory over brief intervals of time. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 102-106.

306. Peterson, L. R. A note on repeated measures in the study of short-term memory. Psychological Bulletin, 1965, 64, 151-152.

Keppel's (1965) objection to averaging over repeated measures is discussed. Several possibilities for minimizing proactive interference are suggested, including increasing time between tests. Consideration is given to acceptance of a constant amount of proactive interference over conditions in which other variables are studied. The advantages of using repeated measures in regard to efficiency as well as interpretation are noted.

307. Peterson, L. R. Reminiscence in short-term retention. Journal of Experimental Psychology, 1966, 71, 115-118.

Lists of 5 paired associates were presented once and recalled after 0, 8, 16, or 24 seconds of interpolated activity. Pairs of words from the last positions in presentation were found to be recalled with decreasing frequency as the interval of interpolated activity began to lengthen, but then they increased in frequency. Earlier pairs in presentation tended to be recalled with greater frequency as the interval lengthened.

308. Peterson, L. R. Short-term memory. Scientific American, 1966, 215, 90-95.

Tests of how long information is retained and the circumstances in which it is forgotten suggest that short-term and long-term memory are closely related but involve some separate mechanisms.

309. Peterson, L. R. Short-term verbal memory and learning. Psychological Review, 1966, 73, 193-207.

A number of paired-associate experiments are examined for evidence of the interaction of a short-term storage with a long-term learning mechanism. Differential effects depending on length of the retention interval are described for duration of the spacing interval between 2 presentations of individual pairs, duration of presentation, and number of repetitions. The rapidly decreasing initial portion of the retention curve with multiple paired associates is considered to be the results of interference and the passage of time. The later portion of the short-term retention curve is considered to largely reflect an associative mechanism which may produce stronger associations with time. A model of the interaction of these mechanisms with a guessing component is presented.

310. Peterson, L. R., Brewer, C. L., & Bertucco, R. A guessing strategy with the anticipation technique. Journal of Experimental Psychology, 1963, 65, 258-264.

The capacity of Ss to utilize memory for recently presented responses to maximize guessing success was studied in 2 experiments. A serial anticipation technique was used with a list of 9 words whose order changed on each trial in Experiment I. In Experiment II the same words were used in a paired-associate task. Ss tended to give responses which had not previously been presented on the current trial. Correct responses increased significantly toward the end of a trial. Omissions increased from beginning to end of a trial. It was considered that a guessing strategy could produce the latter portion of the serial error curve, and in any list-learning inflate estimates of associative strength obtained by scoring anticipations.

311. Peterson, L. R. & Gentile, A. Proactive interference as a function of time between tests. Journal of Experimental Psychology, 1965, 70, 473-478.

Short-term retention of individual trigrams was tested in blocks of 6 tests with within-block intervals of 5 or 16 sec. and 91 sec. between blocks. Recall at retention intervals of 0, 3, and 9 sec. was tested. Recall at the 9-sec. interval was a direct function of intertest interval. Intrusions of a letter from the previous trigrams at a specific position was inversely related to time between tests. The problem posed for interference theory by a decline in proactive interference over a rest interval was considered.

312. Peterson, L. R. & Hillner, K. B. Minimal paired-associate learning. Journal of Experimental Psychology, 1964, 67, 360.

The interval between 2 presentations of 2 paired associates was varied in a short-term retention study. The inferiority of the pair presented 2nd was largely eliminated in a condition in which 10 sec. elapsed between pairings. An explanation in terms of attention was suggested.

313. Peterson, L. R. & James, L. H. Successive tests of short-term retention. Psychonomic Science, 1967, 8, 423-424.

Retention of individual trigrams was studied for six successive tests with counterbalancing of the retention interval of the previous test. Recall after an 18-sec. retention interval was found to become progressively worse in line with findings by Keppel and Underwood. Intrusions during the sixth test were found to display a recency effect.

314. Peterson, L. R. & Kroener, S. Dichotic stimulation and retention. Journal of Experimental Psychology, 1964, 68, 125-130.

Duration of the aftereffects of verbal stimulation to one ear was measured under conditions where Ss concurrently shadowed another message to the other ear. Immediate recall did not approach 100% in any situation. Recall of a single letter was substantial over an interval of 6 sec. Recall of 2 letters was poor. Recall of a cued word was not appreciable unless no other words intervened.

315. Peterson, L. R. & Peterson, M. J. Short-term retention of individual verbal items. Journal of Experimental Psychology, 1959, 58, 193-198.

The investigation differed from traditional verbal retention studies in concerning itself with individual items instead of lists. Forgetting over intervals measured in seconds was found. The course of retention after a single presentation was related to a statistical model. Forgetting was found to progress at differential rates dependent on the amount of controlled rehearsal of the stimulus. A portion of the improvement in recall with repetitions was assigned to serial learning within the item, but a second kind of learning was also found. It was concluded that short-term retention is an important, though neglected, aspect of the acquisition process.

316. Peterson, L. R. & Peterson, M. J. Minimal paired-associate learning. Journal of Experimental Psychology, 1962, 63, 521-527.

The short-term retention of minimal numbers of paired associates was studied in four experiments. Pairs of words were presented in a memory drum and tested for recall by presenting a stimulus after some interval no longer than 16 sec. during which Ss counted backward. Recall decreased as number of pairs increased, but a primacy effect complicated an interpretation in terms of competing responses. This primacy effect was present with either one or two presentations of a pair. When the stimulus situation at recall was extended to include the alternate pair of words, the primacy effect was reduced. Errors at recall were largely words from the set of pairs just presented.

317. Peterson, L. R., Saltzman, D., Hillner, K., & Land, V. Recency and frequency in paired-associate learning. Journal of Experimental Psychology, 1962, 63, 396-403.

The formation of associations between pairs of verbal items was investigated in four short-term retention experiments. Experiment I showed retention to decrease regularly over a 16-sec. interval, although recall was nearly perfect immediately after presentation. In Experiment II the effect of a test without knowledge of results (Test 1) was found to vary with its position between original presentation (P) and a second test (Test 2). Correct recall on Test 2, given correct recall on Test 1, increased as the time between P and Test 1 increased; correct recall on Test 2, given incorrect recall on Test 1, decreased as the time between P and Test 1 increased; error on Test 2, given that error on Test 1, decreased as the interval between tests increased. In Exp. III it was found that the strengthening or interference which resulted from substituting forced pairing of the same or different responses for Test 1 could not completely account for the diverging conditional probabilities in a successive test experiment. In Exp. IV the increase in recall from an unprompted response without knowledge of results was found to be as great as that for a prompted repetition.

The findings are discussed in relation to the all-or-none vs. incremental assumption regarding associative learning, and are interpreted as favoring the latter assumption.

318. Peterson, L. R., Wampler, R., Kirkpatrick, M., & Saltzman, D. Effect of spacing presentations on retention of a paired associate over short intervals. Journal of Experimental Psychology, 1963, 66, 206-209.

Three experiments varying the interval between 2 presentations of paired associates were reported. Other pairs filled the spacing and retention intervals. Pairs consisting of a word and a number as well as pairs consisting of 2 words showed a superiority at 8 sec. and longer retention intervals when presentations were spaced. Increasing the spacing interval beyond 8 sec. did not increase recall, when a 2-sec. rate of presentation was used. A 2-factor explanation of the findings was suggested, in which cue learning was the major factor influencing recall at longer retention intervals, while a 2nd factor was confounded with cue learning at short retention intervals.

319. Phillips, J. L., Shiffrin, R. M., & Atkinson, R. C. Effects of list length on short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 303-311.

A memory experiment has been performed with the following procedure. On each trial of the experiment a display of items was presented in a serial order. At the conclusion of each display S was tested for recall on one of the items. The length of the displays varied from 3 to 14 items. Plotted as serial position curves, the results showed an S-shaped recency effect and a smaller primacy effect. A

specific version of a memory model formulated by Atkinson and Shiffrin (1965) was presented and applied to the data. The model assumes two memory states: a temporary storage state, called the buffer, from which retrieval is perfect; and a long-term storage state called LTS, from which retrieval is imperfect. Both response data and confidence ratings were accurately fit by the model.

320. Pollack, I. The assimilation of sequentially-encoded information. HFORL Report TR-54-5, Air Force Cambridge Research Center, Bolling Air Force Base, Washington, D. C., 1954.

This paper presents a methodology for verbal learning based on the theory of information. The approach allows an objective quantification, in units not specific to the particular experimental operations considered, of (1) the learning materials employed (the informational input), (2) the information lost (the error output), and (3) the information gained (the difference between the informational input and information lost). The units are sufficiently general to allow for comparison of the results of a diversity of experiments. An illustrative experiment in learning designed to fulfill the requirements of the methodology, was reported and the results were briefly considered.

321. Pollack, I. Visual noise filtering by human operators: sequentially encoded information. AFCRC-TR-54-57, Air Force Cambridge Research Center, Bolling Air Force Base, Washington, D. C., 1955.

322. Pollack, I. Ohm's acoustical law and short-term auditory memory. The Journal of the Acoustical Society of America, 1964, 36, 2340-2345.

The ability of listeners to "hear out" individual components of a tone combination was examined under a variety of experimental procedures. Contrary to the expectation of Ohm's acoustical law, listeners were relatively unable to accurately "extract" components from nonharmonically related tone combinations.

323. Pollack, I. Consistency of assignment of ratings in recognition memory. Perceptual and Motor Skills, 1965, 21, 941-942.

It is demonstrated that Ss employ ratings in a consistent manner in recognition memory tasks when exposed to conditions yielding a wide range of recognition scores.

324. Pollack, I. & Johnson, L. Continuing memory span for digits. Perceptual and Motor Skills, 1963, 17, 731-734.

An estimate of the continuing memory span for digits was obtained by having Ss reproduce a sequence of digits after a fixed delay. By this technique, the continuing memory span is only about three digits. The span decreases with rate of digit presentation and is relatively constant between 2 and 4 alternatives per digit.

325. Pollack, I. & Johnson, L. Keeping track of the immediately past states of variables. Perceptual and Motor Skills, 1964, 18, 55-58.

Ss attempted to keep track of the immediately past state of 2 to 8 variables, with 2 to 8 possible states per variable. The delay between presentation and recall of information was substantially more important to this task than either the number of variables or the number of states per variable.

326. Pollack, I., Johnson, L. B., & Knaff, P. R. Running memory span. Journal of Experimental Psychology, 1959, 57, 137-146.

The present series of experiments compared the recall of messages composed of randomly selected digits under two conditions of presentation: (a) uncertain length, in which Ss were uncertain of the length of the to-be-presented message; and (b) certain length, in which Ss were informed of the length of the to-be-presented message. A pilot study revealed digit spans for uncertain-length messages which were considerably smaller than would be expected with certain-length messages. Further studies examined the effects on the recall of uncertain- and certain-length messages of a wide range of experimental variables.

The major findings were:

1. Except for limiting ranges of conditions, as in 100% correct response, recall performance with messages of uncertain length is significantly poorer than performance with certain-length messages under all conditions of testing.
2. The difference in recall performance between certain- and uncertain-length messages is maintained despite considerable amounts of practice. Spans for both types of messages significantly improve with practice. The improvement with practice is not specific to the messages employed.
3. An increase in rate of digit presentation is associated with: (a) a decrease in digit span for both types of messages; (b) a relatively more rapid decrement in the digit span for certain-length messages; and (c) a decrease in variability in digit-span scores.
4. Grouping of the presented digits differentially affects performance with known- and unknown-length messages. There is little effect of grouping on certain-length messages, but significant grouping effects are observed with uncertain-length messages.
5. Control tests under moderate rates of presentation yield equivalent scores for auditory and visual presentation for equivalent experimental conditions.

6. The information per digit only slightly influenced the digit-span scores for certain- and uncertain-length messages.

The results are interpreted in terms of two factors: proactive interference and the behavioral strategy employed by Ss.

327. Pollack, I., Norman, D. A., & Galanter, E. An efficient non-parametric analysis of recognition memory. Psychonomic Science, 1964, 1, 327-328.

A method for efficient evaluation of the results of recognition memory experiments is illustrated. The method is based upon the area under the iso-mnemonic curve relating correct and incorrect acceptances obtained by means of ratings.

328. Pompi, K. F. & Lachman, R. Surrogate processes in the short-term retention of connected discourse. Journal of Experimental Psychology, 1967, 75, 143-150.

A training list of words was presented in a meaningful syntactic order or in random order. In Experiment I, a recognition test was administered containing an equal number of distracter words of high or low thematic association (TA). The TA words were preselected by judges. In Experiment II, the TA words were interpolated between training and a free-recall test. Predicted interactions between Word Order and TA were obtained in both studies. The results suggest that the meaning of connected discourse may be stored as surrogate structures (themes, images, schemata, and words) and that lexical associations to the surrogate system may occur during retrieval.

329. Posner, M. I. Immediate memory in sequential tasks. Psychological Bulletin, 1963, 60, 333-349.

Factor effecting the memory capacity are basic to understanding sequential tasks. The evidence immediate memory is sometimes subject to decay but that interference from interpolated items has a much larger effect. Interference effects are particularly great when the S must hold items in store while responding to previously stored material within an ongoing serial task. The ability of S to use time to reorganize the stimuli for storage works against the decay tendency. Only in rare instances does S store a pure representation of the stimulus; rather, he must be viewed as an active information handler applying his knowledge of the nature of the stimulus and response to reduce his memory load.

330. Posner, M. I. Information reduction in the analysis of sequential tasks. Psychological Review, 1964, 71, 491-504.

This paper proposes a taxonomy of information-processing tasks. Information conserving, reducing, and creating operations are viewed as different methods of processing. The main concern of this paper is information reduction which, it is suggested, represents a kind of thinking in which the solution is in some way implicit in the problem, but in which the input information must be reflected in a reduced or condensed output. A number of tasks within the areas of concept identification and utilization are shown to have this character. If the tasks require complete representation of the stimulus in the response (condensation) the amount of information reduced is directly related to difficulty both during learning and in utilization of previously learned rules. If the tasks allow Ss to ignore information in the stimulus (gating) the direct relation between reduction and difficulty is found during learning but may not occur after the rule is learned.

331. Posner, M. I. Rate of presentation and order of recall in immediate memory. British Journal of Psychology, 1964, 55, 303-306.

University students attempted immediate recall of 8-digit series presented aurally. When subjects were required to report the digits in their presented order, the fast presentation rate (96 digits per minute) was superior to the slow rate (30 per minute). When subjects were required to report the last four digits, before giving the first four digits, this improved performance at the slow rate but not at the fast rate. These data resolve previous conflicting results and tend to support a decay factor in immediate memory.

332. Posner, M. I. Short term memory systems in human information processing. Acta Psychologica, 1967, 27, 267-284.

In this paper, three aspects of the role of memory in information processing have been considered. Retention of images, preservation of verbal information over brief periods, and reactivation of material from long term store represent different senses in which the term STM has been used. The assumption that all of these involve a single system may be fruitful for some purposes, but may also lead to inappropriate generalizations. For example, it does not appear that imagery need be short term or that reactivated information is especially susceptible to interference. Nevertheless, a considerable amount is now known about each of these systems and both comparisons and contrasts may prove useful.

333. Posner, M. I. & Konick, A. F. On the role of interference in short-term retention. Journal of Experimental Psychology, 1966, 12, 221-231.

In a series of experiments the similarity between items presented on a given trial (II) and on successive trials (PI) is systematically manipulated in conjunction with the difficulty of the information processing interpolated between presentation and recall. The results of the studies indicate that under conditions where

forgetting proceeds independently of the effects of interpolated task similarity it depends upon similarity among stored items and upon the difficulty of the interpolated processing. The effectiveness of interference does not appear to vary directly with the difficulty of interpolated processing but is more closely related to the time material is in store. These results are compatible with the view that interfering items work spontaneously during the retention interval to disrupt the original trace (Acid Bath) rather than merely competing at the time of recall.

334. Posner, M. I. & Konick, A. F. Short-term retention of visual and kinesthetic information. Organizational Behavior and Human Performance, 1966, 1, 71-86.

This series of experiments concerns short-term retention of the position of a circle on a line (visual-location) and of the length of a motor movement without visual feedback (kinesthetic-distance). Both tasks show forgetting of information over time intervals up to 30 seconds. Visual-location shows a systematic increase in forgetting as interpolated task difficulty is increased. Forgetting of kinesthetic-distance is unrelated to interpolated task difficulty. Analysis of the data suggests that in both tasks primary retention is through imagery rather than verbal codes. Retention of information about visual-location seems to require the availability of central processing capacity but kinesthetic-distance does not. The implications of these findings for the analysis of perceptual-motor skills and for a general theory of short-term memory are examined.

335. Posner, M. I. & Rossman, E. Effect of size and location of informational transforms upon short-term retention. Journal of Experimental Psychology, 1965, 70, 496-505.

This series of studies investigates the effect of informational transformations of various levels of difficulty, as indicated by the amount of information reduction required, upon material in short-term storage at the time of the transform. Experiment I shows that with number and similarity of interpolated items held constant, the greater the difficulty of a transform the more forgetting will result from it. Experiments II and III show that these effects cannot be attributed entirely to increases in the time an item remains in store. Rather, time in store and difficulty of transform both contribute to determining the amount of forgetting. Experiment IV shows that the loss of material in store is a decreasing function of its distance prior to the transform, but that the transformed material itself shows no decline in retention. These results point to an operational definition of rehearsal as a process requiring part of the limited central capacity of S.

336. Postman, L. Short-term memory and incidental learning. In A. W. Melton (Ed.), Categories of Human Learning. New York: Academic Press, 1964. Pp. 145-201.

337. Poulton, E. C. Memorization during recall. British Journal of Psychology, 1953, 44, 173-176.

1. Presenting S with a rapid series of new items to which responses had eventually to be made, while he was attempting to respond to previously memorized items, affected both his responses to the memorized items and to the new items.

2. It was concluded that new items could not be memorized effectively while previous items were being recalled.

3. This suggested a mechanism which could account for the detrimental effect of actual retention upon the memorization of new items.

338. Poulton, E. C. Sequential short-term memory: Some tracking experiments. Ergonomics, 1963, 6, 117-132.

Twelve naval ratings had to reproduce an irregular wavy track after a time lag. Rate of input and duration of delay were varied systematically in different trials, both with and without preview. Accuracy in reproducing the positions of the reversals in direction of the track was found to depend only upon the time lag: the longer the delay the worse the reproduction. Amount of input held in memory did not have a significant effect. These quite different findings from previous experiments were attributed to the reduced chances for rehearsal and to the reduced importance of order-information. A theoretical analysis is included of the independent variables affecting sequential short-term memory.

339. Pylyshyn, Z. W. The effect of a brief interpolated task on short-term retention. Canadian Journal of Psychology, 1965, 19, 280-287.

This study was directed at demonstrating the effect of temporal location of a brief interpolated task on the recall of visually presented letters. A number of previously omitted controls were introduced. These included using an interpolated task (choice reaction time) which was very brief and quite different from the recall task, maintaining a constant expectancy of an interpolated task even for the control condition in which no interpolated task occurred, and varying the difficulty of both the recall and the interpolated task. The results showed that the largest drop in the recall score occurred when the interpolated task was presented soon after presentation of the stimulus to be recalled. The decrement in recall performance was not very great when compared with the recall when there was no interpolated activity. This differs from previously reported results and suggests that expectancy has an interfering effect.

R

340. Rabbitt, P. M. Short-term retention of more than one aspect of a series of stimuli. Nature, 1962, 195, 102.
341. Rabbitt, P. M. A. Ignoring irrelevant information. British Journal of Psychology, 1964, 55, 403-414.

The task of scanning a visual display to identify certain symbols may involve ignoring the presence of others, and so may be compared with Donders's 1862 study of the 'c-reaction', in which a response was required to only one of a set of five possible phonemes presented to a subject in random succession. For visual displays of letters of the alphabet the time required to ignore a symbol as irrelevant is shown to depend upon the vocabulary of items for which search is conducted. Incidental learning of irrelevant symbols is shown to be related to the same variable. It is shown that performance in situations of this type is analogous to that in which subjects respond to groups of stimuli rather than to particular items, and stimulus and response entropy are independently varied.

342. Reid, L. S., Brackett, H. R., & Johnson, R. B. The influence of relationships among items to be recalled upon short-term retention. Journal of Verbal Learning and Verbal Behavior, 1963, 1, 86-92.

Four experiments are reported in which Ss were required to remember familiar English words until their recall was requested. While remembering these words, Ss were presented other words or asked to recall previously presented items. In all four experiments, the recall of more than one item at a time was typically required. The studies are concerned with the manner in which short-term retention is influenced by the relationships among words whose recall is requested at the same time.

Retention was found to be facilitated by the opportunity to group words of the same generic class (e. g., automobiles, trees, sports, etc.) at recall. On the other hand, if words from the same class had to be simultaneously stored in different groupings for recall, the resulting interference led to poorer retention than was the case when Ss were required to remember only unrelated words at any one time. It was found to make little difference whether the same or different Ss were responding under the various conditions of opportunity to group. Moreover, if the opportunity to group is varied in a stepwise fashion from the condition in which maximum grouping is possible to the condition in which S is required to remember only unrelated words, retention scores are found to be ordered with respect to this variation. However, it is interesting to note that under the task conditions of these experiments, retention is benefited by multiple-item recall, i. e., increased average load reduction, even when the items being recalled are unrelated. While it is possible that these benefits may have been derived in part from the grouping of unrelated

items at recall, it seems more likely that the improvement was due to a decrease in retroactive inhibition that resulted from the concomitant decrease in number of interpolated recall points with increases in average load reduction.

343. Reid, L. S., Lloyd, K. E., Brackett, H. R., & Hawkins, W. F. Short-term retention as a function of average storage load and average load reduction. Journal of Experimental Psychology, 1961, 62, 518-522.

Two experiments are reported in which short-term retention was studied in a situation requiring S to remember familiar English words until their recall was requested. During the time S was required to remember these items he was presented other words or asked to recall previously presented items. Experiment I demonstrated that in a task where the recall of more than one item could be requested at a given point in the sequence, errors increased systematically as the average number of words to be remembered over blocks of recall points, average storage load, was increased. In Exp. II it was found that when the average number of items to be remembered was held constant, errors decreased as the average number of items to be recalled at given recall points, termed average load reduction, was increased.

344. Robinson, G. & Loess, H. Short-term retention of individual paired associates as a function of conceptual category. Journal of Experimental Psychology, 1967, 75, 133-135.

The effect of conceptual category on short-term retention of paired-associates (A-Bs) was tested by utilizing Murdock's (1963) method of presenting a list for a single trial and then testing for the B member of one pair. For different conditions the A members, or the B members, or both, represented a single category. For a control condition, A's and Bs were unrelated words. 90 Ss were tested under all conditions, at all serial positions. The results of the control conditions duplicated Murdock's (1963) findings of a marked recency effect. For the experimental conditions, only when A and B words of a given pair were from the same category and each pair was from a different category did retention differ significantly from the control. As expected, overt intrusions were largely specific to the conceptual category of the response term.

345. Rohrman, N. L. & Jahnke, J. C. Effect of recall condition, presentation rate and retention interval on short-term memory. Psychological Reports, 1965, 16, 877-883.

A total of 300 university students were presented a brief list of non-alphanumeric items and instructed to recall immediately either the items (free, recall, FR), the order in which the items were presented (order recall, OR), or both (serial recall, SR). Presentation rate and retention interval were additional experimental variables in Exp. I and II, respectively. In both experiments significant differences in recall were found between FR conditions and the remaining two, which

did not differ from each other. More items were recalled at the slow than fast rate. Retention interval was not a significant variable. Results suggest that retention will improve when order information is eliminated from recall (Brown, 1958), that the recall of item and order information involve at least partially independent memory processes, and that, while the recall of items may proceed independently of the recall of their order, the converse is not true.

346. Rosenzweig, M. R. & Postman, L. Intelligibility as a function of frequency of usage. Journal of Experimental Psychology, 1957, 54, 412-422.

Parallel experiments were performed in English and French in order to determine whether the intelligibility of words masked by noise varies with the frequency of usage of the words. In each experiment, the items were homogeneous in syllabic length. Correlations between intelligibility scores and log frequency were -.78 and -.65 in the respective experiments, indicating that frequency of usage accounts for about half the variance of the thresholds. Nonsense responses were rare, but in both experiments they were given significantly more often to stimuli of low frequency than to stimuli of high frequency. Most of the incorrect responses were meaningful words, and these tended to be of high frequency of usage. In the English experiment, Ss attempted to recall the stimuli at the end of the threshold test. The high-frequency words, though they had been recognized more often during the threshold test, were not recalled better than the low-frequency words. This effect is attributed to interference among the many high-frequency responses made during the threshold test.

347. Rubenstein, H. & Aborn, M. Immediate recall as a function of degree of organization and length of study period. Journal of Experimental Psychology, 1954, 2, 146-152.

Materials of an earlier study (1) were employed in a further investigation of the influence of degree of organization upon Ss' ability to recall passages on nonsense syllables immediately after learning. Two groups of Ss were intensively trained in the various organizational patterns of the passages. The organizational patterns ranged from random order (high average rate of information) to high organization (low average rate of information). The Ss then tried to memorize a series of experimental passages over a succession of study periods from 1 min. to 20 min. in length. The results of this experiment led to the following conclusions:

1. More information is recalled from material of lower degree of organization than from material of higher degree of organization. This finding is in conformance with results reported earlier (1). However, different amounts of information were recalled from each degree of organization tested--a finding contradictory to the constancy in information recalled from lower degrees of organization obtained earlier. More intensive training of Ss, far from bringing about a constancy in information recalled from every passage, increased the recall differences among the various degrees of organization.

2. The ratio of the information recalled from a pattern of higher degree of organization to the information recalled from a pattern of lower degree of organization is always less than the ratio of their rates of information.

3. The relationship between degree of organization and amount of information recalled is independent of length of study period for shorter study periods. In the longest study periods (10 and 15 min.), there is a tendency for performance in patterns of lower organization to improve disproportionately to performance in patterns of higher organization.

4. The amount of information recalled per unit of study time decreases as the length of study time increases. The "loss" is percentage-wise the same for all degrees of organization.

348. Ryan, S. F. & Whimbey, A. E. STM abilities in LTM tasks. Psychonomic Science, 1968, 10, 297-298.

The study investigated the relationship between STM and LTM using the same type of stimuli and the same format of presentation for both measures. It was shown that Ss who perform well on a reliable span task get similar items into LTM faster than Ss with smaller short term capacities.

S

349. Sampson, H. Stimulus duration and paced performance. Canadian Journal of Psychology, 1958, 12, 7-12.

If stimuli for serial addition are presented visually, and subjects cannot control stimulus frequency (pacing), they give significantly fewer correct verbal responses and miss increasing numbers of stimuli as pacing is accelerated. Moreover, performance under varying pacing depends also on length of time stimuli are "on" and "off." Experiments demonstrating on-off effects (4) suggest that stimulus duration within a pacing interval may be the principal factor. We were concerned specifically with this possibility.

Accordingly, serial addition performance was studied under three conditions: (1) pacing constant, on-off ratios varied; (2) "on" constant, "off" varied; "off" constant, "on" varied; (3) on-off ratios constant, pacing varied.

These experiments should help to clarify the role of stimulus duration in paced performance and thus the broader problem of its role in "timing" (2).

350. Sampson, H. & Horrocks, J. B. Binocular rivalry and immediate memory. Quarterly Journal of Experimental Psychology, 1967, 19, 224-231.

Three experiments examine features of a simple memory task on which right-handed, right eye dominant subjects have been reported to recall digits projected to the right eye more accurately than those projected simultaneously to the left eye. Superior recall by these subjects of information projected to the right eye was observed only when stimuli projected simultaneously to both eyes were seen as overlapped in the binocular percept. Under monocular presentations, accuracy of recall was not related to the eye with which stimuli were viewed. The binocular overlap condition has a significance other than that of simply increasing the difficulty of identifying the elements in a visual display for there were no differences in accuracy of recall from each eye when overlapped stimuli were viewed monocularly. More accurate recall of right eye information appears to reflect the resolution of a conflict between inputs from each eye. The possible relation of this finding to cerebral dominance is also discussed. Order of recall in these experiments depended mainly on spatial cues provided by the experimental situation.

351. Sanders, A. F. Rehearsal and recall in immediate memory. Ergonomics, 1961, 4, 25-34.

Experiments on the influence of rehearsal on the retention and recall of digit combinations are described, from the results of which it appears that a rehearsal period facilitates recall by producing a transition from immediate to permanent memory. It further seems that some parts of the material presented reach permanency very quickly, without much rehearsal, and also that mere transmission of material

by the organism without intention to memorize it, nevertheless has some effect on material in the long-term memory store. It is argued that, during a rehearsal period, the main activity of the subject is not to repeat the material automatically, but to assimilate it with the conditional probabilities of past events.

352. Sanders, A. F. & Van Borselen, J. W. Continuing memory and information processing. Journal of Experimental Psychology, 1966, 71, 844-848.

Digits of the set {2, 3, 4, 6} were successively and randomly presented to Ss, who were instructed to respond to each 2 and 3 after any 2 new digits had passed, and not to respond to 4 and 6. Performance improved with practice. Training a condition where a warning signal was given at times that response was to be made, had no transfer effect on the no-warning signal condition, suggesting the importance of remembering moments to recall. It is hypothesized that Ss in the no-warning signal condition have a storing bias to all new material. This was tested by asking Ss to react nondelayed to 4 and 6, together with the existing tasks. Performance in the warning signal condition was better in that case, but not when the additional task was non-perceptual. RT of 4 and 6 proved much delayed, suggesting incompatibility between rehearsal and direct reaction processes.

353. Scandura, J. M. Concept dominance in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 461-469.

Four groups of 16 Ss were presented with four kinds of list (one, high, low, and no dom) which differed as to the frequency with which the five nouns in a given list elicited a common descriptive adjective. There were two retention intervals (5 and 30 sec). The adjective-recall (AR) group was instructed to state the common adjective immediately after each list was presented. The recall-adjective (RA) group was similarly instructed to do so after attempted recall. The categorization groups (CR and RC) were instructed to classify new nouns. Number of nouns recalled was a function of time and dom level, one > high > low > no dom. The One vs. High and High vs. Low Dom by Time interactions were significant. Retention was poorest in group CR. Adjective identification and retention were correlated at the high and low dom levels after 30 sec. The lack of adjective forgetting suggested that whereas content may be forgotten over time, the storage location itself may not. Mediation and search model interpretation were offered.

354. Scandura, J. M. & Roughead, W. G., Jr. Conceptual organizers in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 679-681.

This study determined the effects on the STM of five noun lists of:
(a) conceptual recoding cues (adjectives) presented prior to the lists, (b) list dominance (high, low, and no dom), and (c) retention interval (1, 5, 15, and 30 sec). Number of nouns correctly recalled was a function of recoding cue, dominance level (high > low > no dom), and time. The recoding cues facilitated retention of the high and low dom lists, but depressed 1-sec recall of the no dom lists. There were relatively more within concept-category noun intrusions during high dom and recoding cue recall than with their controls. Mean latencies between nouns correctly recalled were shorter at 1-sec recall than thereafter, but there were no other differences due to time, recoding cue, or dominance. These results, involving the reorganization

of input, were interpreted in terms of a simple model postulating familiar and unfamiliar storage locations.

355. Schaub, G. R. & Lindley, R. H. Effects of subject-generated recoding cues on short-term memory. Journal of Experimental Psychology, 1964, 68, 171-175.

Associations to 36 high-meaningfulness (HM) trigrams and to 36 low-meaningfulness (LM) trigrams were collected from a group of men and women college students ($N = 20$). Another similar group ($N = 24$) was tested in a short-term memory (STM) study using the Peterson and Peterson (1959) technique. In STM a $2 \times 3 \times 4$ factorial design was used; trigrams were either of HM or LM, retention intervals were 8, 14, or 20 sec., and the trigrams were presented once or twice or they were preceded by a frequently occurring or infrequently occurring association (as determined in the association test with the 20 Ss). Results were that associations to the HM trigrams as compared to the LM trigrams had shorter latencies ($p < .001$), more 1-word associations, and more letter sequences in common between the association and the trigram. In STM the HM trigrams were recalled better than the LM trigrams ($p < .01$), 2 presentations of the trigram produced better recall than 1 presentation ($p < .01$). Preceding the trigram by an association produced better recall than either 1 or 2 presentations of trigram ($p < .01$), and frequently occurring associations produced better recall than infrequently occurring associations only for LM trigrams ($p < .05$).

356. Schnore, M. M. & Partington, J. T. Immediate memory for visual patterns: Symmetry and amount of information. Psychonomic Science, 1967, 8, 421-422.

Immediate recall for visual patterns which varied in degree of symmetry and amount of information (2.5 to 13.7 bits) was studied. It was found that recall errors were primarily a linear function of degree of symmetry and amount of information.

357. Schonfield, D. & Danaldson, W. Immediate memory as a function of intra-series variation. Canadian Journal of Psychology, 1966, 20, 218-227.

While interference has been generally accepted as the main theoretical explanation of forgetting processes, the results of some recent experiments in immediate memory have been interpreted as supporting a "trace fading" hypothesis. Comparisons between interference and fading effects are complicated by the problem of filling the time interval between presentation of stimuli and recall. The experiments reported here attempt to overcome this difficulty by varying the intraseries rate of presentation. While the results of the first experiment can be interpreted as supporting a fading hypothesis, the second experiment demonstrates that fading cannot be the sole source of forgetting in immediate memory. An older group of subjects was included in the first experiment and their recall scores provide some confirmation that the aged are especially vulnerable to fading effects.

358. Schumsky, D. A., Grasha, A. F., Eimer, E. O., & Trinder, J. Intra-list interference in single trial short-term memory. Psychonomic Science, 1967, 9, 545-546.

In a group testing procedure, 480 Ss were given a single trial to learn a list of five nonsense syllables, presented one at a time in order. Subjects were given an interpolated interval of 0, 15, or 30 seconds in which they were required to cancel vowels from lists of random letters. At the end of the interval they were required to recall either the first, middle, or last syllable in the list. Results revealed a significant effect associated only with serial position.

359. Schwartz, F. Morphological coding in short-term memory. Psychological Reports, 1966, 18, 487-492.

Subjects learned lists made up of morphologically distinct blocks of items. In a control condition, items were interleaved. Block presentation increased recall above the baseline. Each added block lowered recall of the preceding block but yielded a net gain. Retroactive loss was greatest on the terminal item and did not extend back more than one block. The findings were discussed in terms of three views of short-term memory (interference theory, decay theory, and a trace diffusion model).

360. Schwartz, F. & Lippmann, F. Cognitive and associative structures in recall. Psychological Reports, 1962, 11, 91-101.

Subjects (N = 154) were tested for immediate memory of 24 nouns embedded in six sentences. Three levels of sentence coherence and two instructions were used; the instructions directed Ss to learn the nouns or to learn the sentences. The results show that Ss remembered the sentences as units, facilitating recall, and tended to forget the sentences as units also. A reciprocal relationship was found between associative and sentence structure determinants of recall. The results were discussed in terms of the facilitating effects of organizational structures in memory and in terms of interference generated by competing modes of organization.

361. Schwartz, F. & Perkins, P. M. Short-term recognition memory. Psychological Reports, 1966, 18, 493-498.

The role of unit structure was investigated in three experiments on short-term recognition memory. The findings indicate that unit structure is a determinant of short-term forgetting. The findings were discussed in terms of decay and interference theory.

362. Schwartz, F. & Perkins, P. M. Structure and uncertainty in immediate memory. Psychological Reports, 1966, 18, 561-565.

Subjects were tested for immediate memory of position in a spatial matrix. The independent variable was the number of alternative positions (uncertainty). It was hypothesized that uncertainty has independent effects during perceptual registration, retention, and retrieval. The results indicated that uncertainty influences the ease of coding during perception; the role of uncertainty during retention was not demonstrated.

363. Scott, K. G., Whimbey, A. E., & Dunning, C. Separate LTM and STM systems? Psychonomic Science, 1967, 7, 55-56.

This study investigated the effects of a previously learned item (LTM) and a newly learned item (STM) on the growth of within list proactive inhibition. It is shown that an item in LTM has a different effect on the within list PI than does an item in STM, thus supporting a dual theory of memory.

364. Scott, K. G., Whimbey, A. E., & Dunning, C. A functional differentiation of STM and LTM. Psychonomic Science, 1967, 7, 143-144.

The study investigated the recovery from within list proactive inhibition while recalling a previously learned item. It is shown that while performing on this item in LTM recovery from proactive inhibition in STM occurred. The result indicates that STM and LTM refer to more than just a time dimension, thus confirming previous findings.

365. Selzer, L. K. & Wickelgren, W. A. Number of items presented and recalled as determinants of short-term recall. Nature, 1963, 200, 1239-1241.

366. Sheldon, J. M. The effect of display update rate on immediate memory. Human Factors, 1964, 6, 57-62.

Display update rate was conceived in this experiment as being resolvable into two components, the duration of each display and the amount of change in the information being displayed from one display to the next. Subjects viewed sequences of displays consisting of four 3-digit numbers. At varying points in the sequence, the subject was required to recall one of the 3-digit numbers from the immediately preceding display. Displays were projected for either 4.8 or 6.8 seconds, and either four or two 3-digit numbers were changed from one display to the next display. The hypothesis that fewer 3-digit numbers would be correctly recalled at higher update rates was not supported.

367. Shepard, R. N. Recognition memory for words, sentences, and pictures.
Unpublished manuscript, Bell Telephone Laboratories, Incorporated, Murray
Hill, New Jersey, 1966.

Ss looked through a series of about 600 stimuli selected at random from an initially larger population. They were then tested for their ability to recognize these "old" stimuli in pairs in which the alternative was always a "new" stimulus selected at random from the stimuli remaining in the original population. Depending upon whether this original population consisted solely of words, sentences, or pictures, median Ss were able correctly to recognize the "old" stimulus in 90, 88, or 98% of the test pairs, respectively. Corresponding estimates of the informational capacity of human memory considerably exceed previously published estimates.

368. Shepard, R. N. & Chang, Jih-Jie. Forced-choice tests of recognition memory under steady-state conditions. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 93-101.

On each trial of a continuing sequence, subjects were presented with a pair of three-digit numbers-one of which had already been presented on some earlier trial. The instructions were to indicate which number in each pair was the "old" one. The probability of correct choice was found: (a) to decrease markedly with delay since the earlier presentation of the old number; (b) to increase slightly with the dissimilarity between the two numbers in the pair (particularly at intermediate delays); and (c) to exhibit little of the decline over trials that might be expected to result from the interference of preceding numbers.

369. Shepard, R. N. & Sheenan, M. M. Immediate recall of numbers containing a familiar prefix or postfix. Perceptual and Motor Skills, 1965, 21, 263-273.

Ss studied and then attempted to reproduce, from memory, each 8-digit number in one of 2 types of series. In the "prefix" type, the last 4 digits of each number were selected at random while the first 4 digits were selected from just 2 familiar 4-digit prefix sequences. In the "postfix" type, this order was reversed so that one of these two familiar sequences always followed the 4 random digits. A predicted finding (with potential implications for schemes for man-machine communication) was that, in comparison with the prefix type of series, numbers from the postfix type resulted in decreases of 20% in time scores and 50% in errors. Also, errors in which Ss substituted one entire prefix or postfix for the other indicated that these 4-digit sequences were handled as coherent wholes.

370. Shepard, R. N. & Teightsoonian, M. Retention of information under conditions approaching a steady state. Journal of Experimental Psychology, 1961, 62, 302-309.

The retention of information was investigated under conditions approaching a steady state. Specifically, for each three-digit number in a protracted sequence of such numbers, Ss responded "old" or "new" depending upon whether they did or did not remember having seen that number at some earlier point in the sequence. Each number was presented twice; but the number of other three-digit numbers intervening between the first and second presentation of the same number was manipulated as the independent variable. The results were as follows:

1. The probability of correct classification of an old three-digit number as "old" was found to be a decreasing function of the number of intervening presentations. Thus "curve of forgetting" dropped (from near 1.00) to about .56 for delays of 50 intervening presentations. Even after such long delays, however, the probability of correct recognition was still well above the "false alarm" probability of classifying a new stimulus as "old."
2. This probability of false alarm was not constant over the series of numbers but, rather, climbed rapidly (from 0.0) at first and then seemed to be slowly approaching an asymptote near .30 after about 200 presentations.
3. A trace model was shown to yield theoretical curves that could be brought into a close fit with the above two curves. The fact that the curve of forgetting departed systematically from a simple exponential decay function was interpretable within the model as indicating that the stimuli were not all equally similar to each other. The shape of the false-alarm curve could be interpreted as indicating that Ss tended to bias their responses towards the response "old" in such a way as to match the objective probability of an old stimulus. Both curves support the notion that traces not only fade away but, at the same time, gradually spread out so as to become increasingly stimulus specific.
4. The fitted curves also made possible the estimation of a lower bound on the amount of information that Ss are able to carry along at any one time during an arbitrarily protracted sequence of three-digit numbers.

371. Silvestri, A., Massa, R. J. & Goldstein, S. Short-term visual memory. Technical Report 63-3, Sensory Communications Laboratory, Boston, Mass., 1963.

In summarizing the material contained in this report, two major points must be considered.

- (1) The experiments reported here demonstrate conclusively that the short-term visual memory of a human observer can be manipulated to enhance transmission of alphanumeric data through the visual system. The mechanisms (intervening

masks) which have been used in our experiments to produce this enhancement apparently do not interfere with the perceptual relations between the stimulus material presented before and after the masks; i.e., white and black masks (and under some conditions, checkerboard masks) still permit the six English letters to be combined into words. The entire question of enhancing this human capability has not yet been resolved, however. It remains to be determined whether the extension of these techniques to many successive partial stimuli can produce a long-term net increase in data retrieval.

(2) The checkerboard mask has been shown to destroy the perceptual organization between aspects of the stimulus without affecting to the same extent the recall of actual English letters in each partial stimulus. Thus, the possibility that rapid erasure of short-term memory can eliminate interference between time-sequential streams of unrelated information remains an extremely interesting one.

If a major conclusion must be drawn from this work, it must certainly be that the line of research discussed herein offers considerable future potential for direct application to information systems using the human receiver as the primary data processor.

372. Simmel, E. C. Use of brief time intervals in the investigation of sequential memory. Psychological Reports, 1964, 15, 232.
373. Sitterly, T. E. Short-term retention of sequentially presented digits as a function of between stimulus interval, stimulus duration, and series length. Doctoral Dissertation, University of Arizona, 1966.

In the area of short-term memory research, some investigators have found that by increasing the presentation rate of sequentially presented digits, retention is decreased, while others have found that increasing the presentation rate increases retention. In order to resolve this disagreement, and to more fully understand some of the other factors which influence short-term retention, an experiment was conducted to examine the effect of digit duration, interdigit interval, and series length.

Ten paid subjects were used in a within subjects analysis of variance design which examined the effect of digit durations and interdigit intervals of 100, 200, 500, and 1,000 msec. Using the visual modality, the digits were sequentially presented in series lengths of 4, 6, 8, 10, 12, and 14 digits in an ascending (4 to 14) and descending (14 to 4) order.

As the length of the digit duration increased, the percentage of the digits recalled increased. Likewise, as the interdigit interval increased, the percentage of digits recalled increased. By increasing the series length, the number of digits retained increased to an asymptotic level which was controlled by the presentation rate.

The most important conclusion derived from this data was that the subjects were able to perceive and encode new stimulus information while simultaneously carrying out the retention process of organization and rehearsal of old information previously presented. The second implication of the study was that the short-term memory system has a limited capacity determined by the rate of stimulus presentation. This rate capacity is exceeded whenever the stimuli are received at a rate higher than about two per second.

374. Smock, C. D. & Kanfer, F. H. Response bias and perception. Journal of Experimental Psychology, 1961, 62, 158-163.

The present study determined the effects of expected source of information on response biases in a quasiperceptual task. It was predicted that response biases, acquired through prior training, would contribute maximally to "recognition" responses under conditions where: (a) Ss expected no additional external information; (b) accuracy of recognition was minimized. Each of 42 Ss was pretrained by pronouncing nonsense words presented for differing number of trials. Following pretraining, Ss were divided into three equal groups. Group ESP read interpolated material concerning extrasensory perception and was then instructed to respond to E's "thought concentration" during the quasiperceptual task situation. Group LNG was given comparable reading material emphasizing subconscious factors in learning and memory and then was instructed to search his memory during the task situation. Group SLP read articles suggesting the effectiveness of subliminal perception and was instructed to respond to "subliminally" presented words during the task situation. No stimulus word was presented during the task situation to any of the groups. Accuracy of responses as measured by trials to recognition, number of words recognized, and recalled words, was significantly greater for Group ESP than either Groups SLP or LNG. The implications of these findings for methodology in perception studies were briefly discussed.

375. Sperling, G. Negative afterimage without prior positive image. Science, 1960, 131, 1613-1614.

A procedure is described which causes an observer to see a negative after image of a visual field without seeing the field itself. This phenomenon is shown to be closely related to ordinary afterimages and to temporal visual masking.

376. Sperling, G. The information available in brief visual presentations. Psychological Monographs, 1960, 74, No. 1 (Whole No. 498).

377. Sperling, G. A model for visual memory tasks. Human Factors, 1963, 5, 19-31.

A model for visual recall tasks was presented in terms of visual information storage (VIS), scanning, rehearsal, and auditory information storage (AIS). It was shown first that brief visual stimuli are stored in VIS in a form similar to the sensory input. These visual "images" contain considerably more information than is transmitted later. They can be sampled by scanning for items at high rates of about 10 msec per letter. Recall is based on a verbal recoding of the stimulus (rehearsal), which is remembered in AIS. The items retained in AIS are usually rehearsed again to prevent them from decaying. The human limits in immediate-memory (reproduction) tasks are inherent in the AIS-Rehearsal loop. The main implication of the model for human factors is the importance of the auditory coding in visual tasks.

378. Sperling, G. Successive approximations to a model for short term memory. Acta Psychologica, 1967, 27, 285-292.

Experimental data are considered from a simple task in which an observer looks at letters and then writes them down. Three models are proposed. Model 1 consists of only two components: a visual memory for the letters and a motor translation component to enable copying a visual memory onto paper. Model 1 is inadequate because the visual image is shown not to persist until the time of reproduction. Model 2 corrects this deficiency by incorporating the possibility of subvocal rehearsal of the stimulus letters and an auditory memory for the rehearsal. However, Model 2 cannot account for performance with extremely short duration images because of the limit on the maximum rehearsal rate. The critical improvement in Model 3 is a more detailed specification of scanning, recognition and rehearsal, including a form of memory which is inherent in the process of recognition itself. Model 3 accounts for these data and incidently gives rise to some interesting inferences about the nature of consciousness.

379. Steffy, R. A. & Eriksen, C. W. Short-term, perceptual-recognition memory for tachistoscopically presented nonsense forms. Journal of Experimental Psychology, 1965, 70, 277-283.

A display consisting of triangular arrangements of 3 Vanderplas and Garvin nonsense forms was tachistoscopically presented. In the center of the triangle a 4th form (cue) occurred which was idnetical to 1 of the 3, and S indicated which of the 3 was identical to the cue. Two sequences of presentation were used: cue occurred 1st followed at delays of 10-700 msec. by the 3 alternatives; alternatives occurred 1st followed by the cue. There were 2 conditions; 1 where the adapting and delay fields of the tachistoscope were dark, and the other where they were illuminated. Thirty-six Ss were run. For dark-adapting and delay fields impairment in recognition was obtained at delays under 100 msec. for both sequences. A marked superiority of the cue followed by alternatives sequence was found in both conditions. This result was shown to be consistent with findings of other studies on short-term memory.

380. Sternberg, S. Retrieval from recent memory: Some reaction-time experiments and a search theory. Paper presented at the Psychonomic Society, 1963.

The effects of positive and negative set with respect to positive and negative responses are discussed. A serial testing process explanation of these effects seems compatible with the data. Possible causes such as uncertainty, information transmission, confusability, practice, associative processes or parallel testing process are considered incompatible.

Two limitations of the serial testing model are discussed. The usage of reaction time as a measure of the information transmitting processes is questioned. It is concluded that if reaction time measures are used, consideration must be given to encoding time and transmission time. (DFF)

T

381. Talland, G. A. Short-term memory with interpolated activity. Journal of Verbal Learning and Verbal Behavior, 1961, 6, 144-150.

In two experiments strings of consonants were presented, ranging in length from one to five items, for retention over intervals of a few seconds. These spoken messages were followed by a three-digit number which gave the S a cue to start serial subtraction or reading and to continue at a set pace until instructed to stop.

Recall was inversely related to message length and, less consistently, to the length of the retention period. Overt repetition of the message increased the probability of recall, as did reading the numbers instead of counting backwards by threes; repetition of the cue number exerted no reliable effect on recall or on proficiency in subtraction. Delay before first subtraction was infrequent or very short, and unrelated to success in recall. Delay between last subtraction and recall increased with the retention period and was longer with unsuccessful than with correct recall. Errors in subtraction were few, and accuracy of counting had no detectable effect on recall. Failure to keep the prescribed pace in counting was common and tended to be associated with failure in recall; failure to read at the set rate tended to be associated with success in recall. These findings are interpreted as indicating that an important effect of the interpolated activity on short-term retention is its disruption of the original task set.

382. Tarpy, R. M. & Glucksberg, S. Effects of incentive and incentive-cue position on short-term retention. Psychonomic Science, 1966, 5, 313-314.

Ss recalled CCC trigrams differing in incentive value, temporal position of incentive cue, and length of retention interval. Recall varied as a function of incentive and retention interval, but was unrelated to cue position. Additional evidence suggested that differential learning and covert rehearsal may mediate the facilitative effects of incentive.

383. Taub, H. A. Effects of differential value on recall of visual symbols. Journal of Experimental Psychology, 1965, 69, 135-143.

The effects of differential ratio of value, exposure time, and number of categories upon the detection and report of letters were investigated in a visual search task. The differential ratios of value of the letters were 2 : 1, 4 : 1, 8 : 1, and 16 : 1; the exposure times of the stimulus slides were 0.5, 1.5, and 2.5 sec.; and the numbers of categories on a slide were 4, 6, 8, 10, and 12 letters. The results indicated that Ss made more correct identifications, initial responses, and false reports of higher value symbols than of lesser value. Further, the percentage of correct identifications and percentage of initial responses of higher value symbols varied with exposure time and ratio. These effects were attributed to selective recall from short-term memory storage.

384. Taub, H. A. Visual short-term memory as a function of age, rate of presentation, and schedule of presentation. Journal of Gerontology, 1966, 21, 388-391.

Free recall of ten series of nine visually presented stimuli was measured for 40 young and 40 aged Ss as a function of two rates and two schedules of stimulus presentation. Analyses of results indicated that the old groups of Ss recalled less of the stimuli than the respective young groups, but that both young and old Ss improved in performance as rate of presentation was decreased. Schedule of presentation had no consistent effect upon recall scores. Analyses of commission errors indicated that aged Ss made significantly more incorrect responses than the young. The results of both the recall scores and the commission errors were taken as support for the hypothesis that the major losses due to age are related to interference in the storage and retrieval of new information.

385. Taub, H. A. Age differences in memory as a function of rate of presentation, order of report, and stimulus organization. Journal of Gerontology, 1968, 23, 159-164.

Two experiments investigated the effects of order of report, rate of stimulus presentation, number of stimuli, and level of stimulus organization upon the first and second half reports of young and old Ss. It was found that age-related differences were present only in the second half reports and that age did not interact with any of the other variables. The combined results from both experiments were consistent with an interference model and suggest that the major age-related decrements are related to interference during the response phase of the task.

386. Taub, H. A. & Greiff, S. Effects of age on organization and recall of two sets of stimuli. Psychonomic Science, 1967, 7, 53-54.

Short-term recall of sequences of 8 letters was measured for 12 young and 12 aged Ss in a control condition with a single stimulus set and three experimental conditions which differed in arrangement of two sets of color-coded stimuli. The results indicated that there were no differences in performance for the stimuli to be recalled first, while both age and conditions were significant effects for the stimulus set to be recalled second.

387. Taub, H. A., Monty, R. A., & Laughery, K. R. Keeping track of sequential events: effects of stimulus on-time and interstimulus off-time. Perceptual and Motor Skills, 1967, 24, 159-166.

Ss were required to keep track of the number of occurrences of each of four different letters (categories) presented sequentially as a function of the total number of letters presented (trial length), the rate of presentation, and the two components which, when combined, constitute the rate, namely, stimulus on-time and the interstimulus interval or off-time. In general, performance varied inversely

with trial length and rate of presentation. Of greater importance, however, was the complex interaction between the rate of presentation and the components of that rate. At the fastest rate, performance was relatively invariant as a function of these components; at intermediate rates the shortest on-time led to the best performance, while at the slowest rate the shortest on-time led to the poorest performance. The observed results are explained primarily in terms of the time available for rehearsal.

388. Teichner, W. H. Perception and short-term memory in the identification of multisymbol displays. Journal of Experimental Psychology, 1963, 65, 407-413.

It has been suggested that a direct estimate of the amount of immediate forgetting in responding to multisymbol displays may be obtained as the difference between the spans of perception (a count of the symbols) and of short-term memory (number of named symbols). An experiment was designed to determine whether the procedure used to obtain this difference produced an artifact due to differences in sets rather than a memory measure. The results failed to support this possibility. They did suggest that the accuracy of naming is increased when S both counts and names. In addition, the results, extending those of previous studies, suggested that both spans may become asymptotic with slightly more than 9 displayed symbols.

389. Teichner, W. H. Subjective information as a function of source information. Human Factors, 1964, 6, 241-252.

Three experiments are reported in which subjective information, defined as the amounts of information in judgments of number and frequency of events, was studied. Results suggest different phenomena according to whether judgments are made relative to the display or to the source from which the display is a sample. The results also suggested a variety of other phenomena regarding the effects of number of events at a time, redundancy and the rate time of information presentation on subjective information.

390. Teichner, W. H., Christ, R. E., & Fergenson, E. Effects of target value and the interaction of short- and long-term memories on human information processing. Report No. 1, Contract No. Nonr 3357 (06), University of Massachusetts, Amherst, Mass., 1965.

Six major experiments were conducted to examine the effects of target value upon the reporting of briefly exposed symbolic data and to consider the interaction of this variable with a proposed interaction between short- and long-term memory. The accuracy of reporting the high-valued stimuli was, in general, superior to that of the low-valued stimuli but this relationship appeared to depend upon the method of payoff employed. It was also found that as the number of values exceeded two, there were decreasing levels of accuracy. It was, furthermore, concluded that completely unfamiliar, non-naturally sequenced stimuli would have to be used to successfully investigate the relationship between short- and long-term memory.

391. Teichner, W. H., Reilly, R., & Sadler, E. Effects of density on identification and discrimination in visual symbol perception. Journal of Experimental Psychology, 1961, 61, 494-500.

Twenty-four Ss viewed a series of 200 slides presented with a 1-sec. exposure. The slides varied in number of different letters (categories) contained and density of the categories. All slides varied randomly in letter location. Half of the Ss identified the categories; half of them reported the number of categories displayed. The series of slides was presented in random sequence and two variations of grouped density. For the experimental conditions used, the following conclusions appear warranted:

1. For identification of categories, percentage correct identification is inversely proportional to number of categories; percentage of omissions is directly proportional to number of categories; percentage of commissions is a negatively accelerated decreasing function of categories reaching zero by five or six categories.
2. The maximum number of categories that can be identified in this situation without error is represented by not more than 1 or 2 bits of stimulus information.
3. Neither presentation method nor density affected identification or discrimination except that for the discrimination task, densities greater than one impaired performance.
4. A distinction must be made between information processed as identified categories and as discriminated categories or between perceptual capacity and short term memory capacity. The results indicate that perceptual capacity is the greater of the two.

392. Teichner, W. H. & Sadler, E. Effects of exposure time and density on visual symbol identification. Journal of Experimental Psychology, 1962, 63, 376-380.

Twelve Ss were presented with displays of alphabetic letters which varied in number of different letter categories, letter density, and exposure time. On the basis of a previously-made experimental distinction between perceptual capacity and short-term memory capacity, it was predicted that at short exposure times, increasing density would increase letter identification, but that at longer exposure times the opposite effect would be obtained. The results were in the direction of the prediction and in addition appeared to warrant the following specific conclusions for the situation studied:

1. Up to at least five symbols, percentage correct identification is a negatively accelerated increasing function of exposure time up to 2.5 sec. after which a limit is approached.

2. Percentage correct identification is approximately inversely proportional to the number of symbol categories (amount of displayed information).

3. The percentage of omitted symbols is a negatively accelerated decreasing function of exposure time with a limit of approximately 2.5 sec.

393. Teichner, W. H. & Wagner, M. Visual after-images as a source of information. Human Factors, 1964, 6, 141-156.

This report is concerned with the ability of observers to extract data from induced retinal after-images as a means of increasing the display exposure time in single glimpse situations. It was found that observers can use after-image data, and that the gain in reporting to be expected will be greatest for those situations where, without after-images, reporting is most difficult, that is, under conditions of high display load or very short exposure time. The benefit demonstrated was associated primarily with the positive after-image; however, the negative after-image was not ruled out as a persistent data source.

394. Thorpe, C. E. & Rowland, G. E. The effect of "natural" grouping of numerals on short-term memory. Human Factors, 1965, 7, 38-44.

When individuals undertake to memorize long sequences of items, they show a strong tendency to break the sequences into smaller subgroups. This type of spontaneous grouping can be called "natural" grouping. This report reveals that certain specific grouping patterns are spontaneously utilized significantly more often than others for various particular sequence lengths. Furthermore, those persons who employ these "natural" grouping patterns obtain significantly better recall results. The most "natural" subgroup size was found to be three digits with two digits being the next most "natural."

These findings should be useful for any application in which number codes are used (telephone numbers, license plates, stock numbers, etc.).

395. Tulving, E. & Arbuckle, T. Y. Sources of intratrial interference in immediate recall of paired associates. Journal of Verbal Learning and Verbal Behavior, 1963, 1, 321-334.

This experiment was concerned with intralist retention of paired associates. On the basis of the observation that an item is practically always recalled immediately after its presentation and that its recall is less than perfect when other items are presented for learning (input) and attempted recall (output) in the intralist retention interval, two sources of intratrial interference, associated with the operations of inputting and outputting, were postulated as being responsible for the decreasing availability of the learned item in recall.

An experimental design was used that permitted the separation, and the evaluation of the effects, of these two sources of interference. This was done by systematically varying the sequence in which list items were recalled. Each of 50 Ss learned 20 lists of ten paired associates under different conditions of input and output sequence on a single trial. The results can be summarized as follows. (1) In general, probability of recall of an individual item is greatly affected by the position of the item in the input and output sequence. (2) When the item in the last input position is recalled in the first output position, its retention is practically perfect. (3) The probabilities of recall of items under other combinations of input and output position vary considerably, in some cases being as low as .20. (4) The recall of items in early input positions is relatively little affected by their position in the output sequence. (5) The recall of items in late input positions decreases systematically with their position in the output sequence.

These findings were evaluated in the light of the two hypothesized sources of intratrial interference. Apart from the finding of primacy effects--higher recall of early input items than of middle input items--the data seemed to reflect the operation of input and output interference. The previously reported findings that the shape of the serial position curve differs under conditions of serial and free recall were discussed in terms of the observed interaction between input and output position of individual items. Some implications of the findings for the problem of one-trial versus incremental learning of associations were also briefly mentioned.

396. Tulving, E. & Arbuckle, T. Y. Input and output interference in short-term associative memory. Journal of Experimental Psychology, 1966, 72, 145-150.

A single paired-associate unit (critical unit) was presented in a fixed position in a series of other similar units and its recall tested either once or twice, following various combinations of interpolated inputs and outputs in the short retention intervals. Probability of recall of the critical unit on the 1st test was higher following 2 interpolated outputs than 2 interpolated inputs, while probability of recall on the 2nd test seemed to depend on the nature of interpolated events in a more complex fashion. The findings were interpreted in terms of differences in the ease of coding the critical unit with respect to its position in the input and output sequences.

397. Tulving, E., McNulty, J. A., & Ozier, M. Vividness of words and learning to learn in free-recall learning. Canadian Journal of Psychology, 1965, 19, 242-252.

Eighty-two words of approximately equal frequency-of-occurrence value were rated for vividness (V) and meaningfulness (M) by two independent groups of 100 raters. From this set of words three lists of 16 words each were then constructed. The lists varied in V, but were equal in M. They were used as learning materials in an experiment that was designed (1) to investigate the relation between V and free recall, and (2) to demonstrate learning to learn effects. The results showed that Ss learned lists of higher V more readily than the list of low V, and subsequent lists more readily than the first. Subjective organization (SO) scores were related to both vividness and learning to learn effects.

398. Tulving, E. & Patterson, R. D. Functional units and retrieval processes in free recall. Journal of Experimental Psychology, 1968, 77, 239-248.

The Ss recalled lists of 12, 16, 20, and 24 common words on a single trial. Four types of lists were used. C lists consisted of unrelated words, while E, M, and D lists contained 4 highly related words in addition to unrelated words. The 4 highly related words appeared as a cluster at the end of E lists, in the middle of M lists, and were distributed throughout each list in D lists. Recall of words was highest for M lists, followed by E, D, and C in this order. The number of recalled functional units, however, was identical for M and C, and lower in E than in M and C. The findings suggested that (a) highly related words are retrieved from secondary memory as a single functional unit, (b) unitization of related words in primary memory occurs only to a small extent, and (c) the number of retrieved functional units is independent of the size of the units. Models of free recall postulating two types of memory store and transfer of information from one store to the other appear to be inconsistent with the data. A most appropriate view seems to be one according to which primary and secondary memory represent different types of retrieval mechanism.

399. Tulving, E. & Pearlstone, Z. Availability versus accessibility of information in memory for words. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 381-391.

The Ss learned, on a single trial, lists of words belonging to explicitly designated conceptual categories. Lists varied in terms of length (12, 24, and 48 words) and number of words per category (1, 2, and 4). Immediate recall was tested either in presence or absence of category names as retrieval cues. Cued recall was higher than noncued recall, the difference varying directly with list length and inversely with number of items per category. This finding was interpreted as indicating that sufficiently intact memory traces of many words not recalled under the noncued recall conditions were available in the memory storage, but not accessible for retrieval. Further analysis of the data in terms of recall of categories and recall of words within recalled categories suggested two independent retrieval processes, one concerned with the accessibility of higher-order memory units, the other with accessibility of items within higher-order units.

400. Turvey, M. T. The structure of order error in the build-up of proactive interference in short-term memory. Psychonomic Science, 1968, 11, 213-214.

Order errors produced in the generation of proaction in the short-term retention of trigrams were analyzed in terms of their phonemic similarity to the correct items. Employing five successive applications of a short-term memory distractor technique with a 12 sec retention interval it was observed that items transposed within a trigram were phonemically related to the correct items but position intrusions from preceding trigrams were not. Both types of error-production remained invariant across the five trials. The data were considered in the framework of models of order storage in short-term memory.

401. Turnage, T. W. Unit-sequence interference in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 61-65.

An investigation of unit-sequence interference in short-term memory was performed using high- and low-frequency English words. The retention tests were at 2, 5, 15, and 30 sec, and the performance measures were latency of response, S's confidence in his response, and the frequency of correct responses. The latter measure was evaluated by a modified statistical technique for computing linear and quadratic regression coefficients. The experimental results confirmed the presence of proactive interference from linguistic sources, in support of the unit-sequence hypothesis, as well as from repeated measurements performed in the laboratory. A major conclusion, consistent with all measurements taken, was that meaningfulness may favor original learning but not retention in short-term memory when unit-sequence interference is being considered.

402. Turvey, M. Evidence of a connotative dimension in short-term memory as a function of retention interval. Psychonomic Science, 1967, 9, 547-548.

The possibility of a connotative dimension operating in STM was investigated by the use of an RIP design. Connotative difference between items did not facilitate recall at a retention interval of 12 sec but was found to be significantly effective at a retention interval of 24 sec. The results were discussed in terms of the notion that the manifestation of higher-order codes is time dependent.

U

403. Underwood, B. J. & Ekstrand, B. R. An analysis of some shortcomings in the interference theory of forgetting. Psychological Review, 1966, 73, 540-549.

Tests of interference theory of forgetting as applied to extraexperimental sources of interference have been generally negative. The hypothesis was tested that the negative findings result from the fact that linguistic associations, presumed to interfere, do not do so because of their high level of learning, the distribution of their learning over time, or both. The A-B, A-C paradigm was employed, with A-B being varied from 12-80 trials, and was learned either by massed practice or by distribution of practice over 4 days. Recall of A-C after 24 hrs. showed that distribution of A-B resulted in only small proactive inhibition (PI), while massing resulted in heavy PI. Degree of A-B learning influenced the recall only under massed A-B learning. Some implications for the development of forgetting theory were presented.

W

404. Walker, E. L. & Tarte, R. D. Memory storage as a function of arousal and time with homogeneous and heterogeneous lists. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 113-119.

This study is one of a series designed to test a general theory of perseverative consolidation. The theory states the expectations that consolidation will be accompanied by a negative bias against repetition during its course and that an increase in arousal will produce an increase in the negative bias against repetition as well as an increase in the ultimate capacity to recall.

Seventy-two Ss were divided into 9 groups. Learning consisted of one trial with a list composed of 8 stimulus words and single digit numbers as response items. Three groups learned a high-arousal list, 3 groups a low-arousal list, and 3 learned a mixed list. Within each list type, one group recalled the list at 2 min. after learning, one group at 45 min., and one group at 1 week.

The low-arousal list showed high immediate recall which decreased with time. The high-arousal list showed some rise in recall with time. Other analyses agreed with the results of Kleinsmith and Kaplan (1963b) showing high immediate and low ultimate recall for items learned under low arousal, and low immediate recall and high ultimate recall for items learned under high arousal.

Analyses are presented to account for the strong recency effect in the serial position curve for 2-min. recall in terms of short-term memory, and to account for the strong primacy effect in the one week recall serial position curve on the basis of arousal by serial position.

405. Waugh, N. C. Serial position and the memory-span. American Journal of Psychology, 1960, 73, 68-79.

The initial and terminal memory-spans were defined as the mean number of consecutive items recalled correctly before the first failure in recall from the beginning and end of a series, respectively. In one experiment, the terminal span did not vary with the total length of the series presented when this length was unknown to S and when the sub-series to be recalled was preceded by five or more items. A method of constant stimuli and a method of first errors yielded similar terminal spans under this condition. When this sub-series was not preceded by any items, the values of the initial and terminal spans determined by the method of first errors tended to fall below the values of these functions determined by the method of constant stimuli. In a second experiment, the span-functions obtained with a 12-item series were predicted by an hypothesis that asserts the independent combination of the conditional probabilities observed for the recall of item i from the beginning and item $13-i$ from the end of an 18-item series.

406. Waugh, N. C. & Norman, D. A. Primary memory. Psychological Review, 1965, 72, 89-104.

A model for short-term memory is described and evaluated. A variety of experimental data are shown to be consistent with the following statements. (a) Unrehearsed verbal stimuli tend to be quickly forgotten because they are interfered with by later items in a series and not because their traces decay in time. (b) Rehearsal may transfer an item from a very limited primary memory store to a larger and more stable secondary store. (c) A recently perceived item may be retained in both stores at the same time. The properties of these 2 independent memory systems can be separated by experimental and analytical methods.

407. Weiner, B. Effects of motivation on the availability and retrieval of memory traces. Psychological Bulletin, 1966, 65, 24-37.

A review which analyzes a vast array of studies relating motivation and memory is presented. Investigations in which the motivational manipulation occurred during trace formation are distinguished from studies in which the manipulation occurred during trace storage or trace retrieval. The review includes a series of investigations by the author which varied the incentive for retaining stimuli. The general conclusion is that many studies in the area are methodologically inadequate, and have yielded conflicting results. However, there are studies which provide strong evidence that memory can be influenced by nonassociative factors.

408. Weiner, B. Motivation and memory. Psychological Monographs, 1966, 80, 1-22.

Fifteen studies which examine the effects of motivation on memory are presented. It was demonstrated that the effects of motivation on retention are in part determined by the magnitude of incentive, quality of incentive, nature of the activity intervening between stimulus onset and recall, place in the memory sequence at which the motivational factor is introduced, type of stimuli, and type of experimental design. It is suggested that research in the area may require both between-Ss and within-Ss experimental designs. Rehearsal, repression, and action decrement are discussed briefly.

409. Weiner, B. Motivational factors in short-term retention: II. Rehearsal or arousal? Psychological Reports, 1967, 20, 1203-1208.

Two experiments which investigate the effects of motivation on memory are reported. In the initial study it was demonstrated that recall instrumental to shock avoidance enhances short-term retention. By varying the difficulty of the task interpolated between stimulus onset and recall it was established that the augmented recall is not mediated by covert rehearsal. In Exp. II the motivational information (arousal) occurred at 1, 3, or 5 sec. after stimulus and response offset. Arousal after the stimulus and response terms facilitated immediate recall, although there

were no significant differences in retention as a function of the time of the motivational input. The effects of arousal on retention and the relationship of motivation to trace storage and trace retrieval were discussed.

410. Weiner, B. & Walker, E. L. Motivational factors in short-term retention.
Journal of Experimental Psychology, 1966, 71, 190-193.

In a short-term memory task the to-be-remembered stimuli were cued for different incentive values. Four incentive conditions were employed: win 1¢ for correctly retaining the stimulus, win 5¢, receive a shock for not correctly recalling the stimulus, and a control group where neither shock nor money was used as an incentive. Results indicated that there was a significant interaction ($p < .01$) between time of recall and the incentive condition. The results suggest that motivation affects the capacity to retain material in storage.

411. Wickelgren, W. A. Acoustic similarity and intrusion errors in short-term memory. Journal of Experimental Psychology, 1965, 70, 102-108.

Thirty-six undergraduates were given lists of 8 items (4 digits and 4 letters) presented at .75 sec/item with ordered recall instructions. Ss were either to copy the items as presented and then recall or to recall the items without prior copying. Recall after copying was slightly worse than recall without copying ($p < .05$). In both conditions, intrusions similarity ($p < .001$). Vowel similarities were more important than consonant similarities, but both effects were significant ($p < .001$). There was a correlation of .58 between the number of letters similar to a presented letter and the frequency with which that letter was forgotten ($p < .01$). Short-term memory appears to use an auditory or speech-motor code.

412. Wickelgren, W. A. Distinctive features and errors in short-term memory for English vowels. Journal of Acoustical Society of America, 1965, 38, 583-588.

Errors in short-term recall of 23 English consonants were tabulated and related to three distinctive-feature systems. The consonants were always presented in initial position in a consonant-vowel diagram, and the vowel was always /a/. Subjects were instructed to copy a list of consonants as it was being presented, followed by recall of the list. Perceptual errors were excluded from the recall-error matrix by scoring for recall only correctly copied consonants. The data were also analyzed in such a way as to eliminate differences in response bias for different consonants. Having controlled for response bias, each feature system makes predictions about the rank order of different intrusion errors in recall. Each of the three feature systems was significantly more accurate than chance in these predictions, but the most accurate system was one developed in the present study. This system is a slightly modified version of the conventional phonetic analysis of consonants in terms of voicing, nasality, openness of the vocal tract (manner of articulation), and place of articulation. The results suggest that a consonant is coded in short-term memory, not as a unit, but as a set of distinctive features, each of which may be forgotten at least semiindependently.

413. Wickelgren, W. A. Short-term recognition memory for normal and whispered letters. Nature, 1965, 206, 851-852.

414. Wickelgren, W. A. Short-term memory for phonemically similar lists. American Journal of Psychology, 1965, 78, 567-574.

In the first experiment 31 Ss attempted ordered recall of two types of 9 letter lists: phonemically similar lists in which all letters had a common vowel phoneme (ä, ē, or ö) and phonemically different lists whose letters had no common phoneme. Ordered recall was poorer for similar lists ($p < 0.001$), but this resulted entirely from poorer recall of the position of similar letters ($p < 0.001$). Item-recall, by a free recall criterion, was not significantly different for the two types of lists. In the second experiment 28 Ss attempted ordered recall of the consonants only, from two types of lists of seven consonant-vowel diagrams: phonemically similar lists in which the vowel was identical for all seven diagrams (ä, ē, i, ö, oo) and phonemically different lists whose seven vowels were a mixture of the above five vowels. Position-recall was significantly poorer for phonemically similar lists ($p < 0.001$), but item-recall was significantly better for similar lists ($p < 0.001$).

415. Wickelgren, W. A. Associative intrusions in short-term recall. Journal of Experimental Psychology, 1966, 72, 853-858.

Thirty MIT undergraduates listened to a list of 9 letters presented at the rate of 4 letters per second and then attempted to recall the letters in order. Some lists contained repeated letters, and some did not. The letters following repeated letters tended to be substituted for each other in recall, by comparison to the frequency of confusing letters in the same positions of lists without repeated letters. Such substitutions were called "associative intrusions," and the associative-intrusion phenomenon was observed whether the repeated letters occurred at the beginning or the middle of the list, whether 1 or 2 items separated the repeated letters, and whether the items following the repeated items did or did not have a vowel phoneme in common. The results were interpreted as supporting an associative theory of short-term memory.

416. Wickelgren, W. A. Consolidation and retroactive interference in short-term recognition memory for pitch. Journal of Experimental Psychology, 1966, 72, 250-259.

Ss listened to a standard tone for 2, 4, or 8 sec., followed by an interference tone lasting 2, 4, or 8 sec., followed by a comparison tone lasting 2 sec., followed by a 4-sec. period in which they decided whether the standard and comparison tones were the same or different and stated their confidence on a scale from 1 to 5. Operating characteristics were approximately straight lines on normal-normal paper, and d' values were computed for each condition for each of 10 Ss. The d' value for a condition is a measure of the difference in strength of the correct and incorrect comparison tones at the time of the test, greater d' meaning more accurate performance.

By this measure, trace strength increased with longer duration of the standard tone, decreased with longer duration of the interference tone, and generalized to adjacent tones.

417. Wickelgren, W. A. Distinctive features and errors in short-term memory for English consonants. Journal of Acoustical Society of America, 1966, 39, 388-398.

Errors in short-term recall of six English vowels (I, e, æ, U, ʌ, ə) were tabulated and related to several distinctive-feature systems. Vowels were embedded in two contexts: /lɪlk/ and /zɛlk/. Subjects were instructed to copy items as they were presented, followed by recall of the entire list of (six) items. Perceptual errors were excluded from the recall error matrix by scoring for recall only correctly copied items. The rank-order frequency of different intrusions in recall of each presented vowel was almost perfectly predicted by a conventional phonetic analysis in two dimensions: place of articulation (front, back) and openness of the vocal tract (narrow, medium, and wide). The error matrix also supported the assumptions that the values of openness are ordered in short-term memory and that the correct value on the openness dimension is more likely to be forgotten than the correct value on the place dimension. The study suggests that a vowel is coded in short-term memory, not as a unit, but as a set of two distinctive features, each of which may be forgotten independently.

418. Wickelgren, W. A. Numerical relations, similarity, and short-term recognition memory for pairs of digits. British Journal of Psychology, 1966, 57, 263-274.

Recognition memory for pairs of digits after a 6 sec interference task was superior for pairs containing a zero or one and for pairs consisting of two identical digits than for 'ordinary' pairs. Pairs consisting of digits in forward or backward sequence (e. g. 56 or 43) and pairs where one digit is a multiple of the other were remembered slightly better than 'ordinary' pairs. False recognition rates were highest for test pairs that had the highest degrees of 'identical elements' similarity to the presented pair (two identical digits in reversed positions or one identical digit in the same position as in the presented pair). The results are discussed in terms of an associative theory of short-term recognition memory.

419. Wickelgren, W. A. Phonemic similarity and interference in short-term memory for single letters. Journal of Experimental Psychology, 1966, 71, 396-404.

One hundred seventy two Ss copied a list of PI letters, then copied a single letter to be recalled later, then copied a list of RI letters, and then attempted recall of the single letter. The length (0, 4, 8, or 16 letters) and phonemic similarity (0, 25, 50, 75, or 100% similar letters) of the PI and RI lists were varied systematically. Both PI and RI were demonstrated in STM for single letters ($p < .001$). RI continued to increase with increasing length of RI lists; PI did not increase appreciably

beyond 4 letters. Both PI and RI increased with increasing phonemic similarity of the PI and RI lists for low and medium degrees of similarity of the other interference list, RI or PI list, respectively ($p < .001$). The findings suggest a 2-factor theory of forgetting in STM, involving retrieval interference and decay or storage interference.

420. Wickelgren, W. A. Short-term recognition memory for single letters and phonemic similarity of retroactive interference. Quarterly Journal of Experimental Psychology, 1966, 18, 55-62.

Copying 12 letters produces more retroactive interference in recognition memory for a single letter when the interference letters possess a vowel sound in common with the letter to be remembered than when they do not. Compared to interference lists that do not include the presented letter, inclusion in the interference list of the letter to be remembered improves recognition memory when the other interference letters have no vowel sound in common with the letter to be remembered, but not otherwise. False recognition rates are greater when the test letter contains a vowel sound in common with the presented letter than when the vowel sounds of these two letters are different. The findings are in complete accord with analogous findings for short-term recall and indicate that short-term recognition memory uses the same phonemic-associative memory system as short-term recall.

421. Wickelgren, W. A. Exponential decay and independence from irrelevant associations in short-term recognition memory for serial order. Journal of Experimental Psychology, 1967, 73, 165-171.

A test of association between 2 adjacent items in a digit series was provided by giving S a test pair of items and having him decide whether the response member of the pair followed the stimulus member in the preceding digit series. Probabilities of correct and incorrect recognition from various conditions were used to estimate the strength of the associations in short-term memory using the operating characteristic of signal-detection theory. A mathematical model for serial-order recognition memory was proposed which assumed that the strength of interitem associations decays exponentially and that S's response in a recognition test depends on the strength of the test association in relation to a criterion, not upon the strength of that association relative to the strength of other associations to the same test stimulus.

422. Wickelgren, W. A. Rehearsal grouping and hierarchical organization of serial position cues in short-term memory. Quarterly Journal of Experimental Psychology, 1967, 19, 97-102.

Lists of 8, 9, or 10 digits were presented at the rate of 1 digit/sec. to subjects instructed to rehearse silently the digits in non-overlapping groups of 1, 2, 3, 4, or 5 digits, after hearing each digit. Subjects were instructed not to rehearse any digits outside the group currently being presented. Rehearsing in 3's was op-

timal, irrespective of list length. Both recall of items and recall of the correct positions of items improved from 1's to 2's to 3's. Recall of items declined very little from 3's to 4's to 5's, but recall of position declined sharply. Errors in positioning digits tended, above chance, to be in the same group or the same position in a different group. The results suggest that both item-to-item associations and serial position-to-item associations are formed in short-term memory, that only two or three serial position cues are used, but that these serial position cues can be hierarchically organized into a beginning, middle, and end group and a beginning, middle, and end position within a group.

423. Wickelgren, W. A. & Norman, D. A. Strength models and serial position in short-term recognition memory. Journal of Mathematical Psychology, 1966, 3, 316-347.

A number of continuous strength models for memory are developed for and tested by an experimental study of recognition memory for three-digit numbers at all serial positions in lists of length two through seven. Empirical estimates of trace strength in different conditions, independent of response bias, are obtained by means of the operating characteristic. The principal theoretical findings are: (a) strength in short-term memory (STM) appears to decay exponentially with the number of subsequent items; (b) subjects report that they recognize an item if and only if strength in memory exceeds a criterion; (c) the first item of a list is remembered better than subsequent items because it receives a greater increment in strength in STM upon presentation, not because it decays more slowly in STM or because it acquires some strength in a long-term memory.

424. Wickens, D. D., Born, D. G., & Allen, C. K. Proactive inhibition and item similarity in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 440-445.

The experiment investigated the effect of proactive inhibition in short-term retention as a function of degree of similarity between the proactive items and the critical test items. When the same class of material, CCC's or NNN's, was used for proactive and test items, marked interference was obtained with as few as three proactive items. No evidence for proactive inhibition was found when the proactive and test items were drawn from different classes of materials, CCC to NNN, or vice versa. There was no evidence that formal similarity (same units in proactive items as in test items) produced greater interference than that obtained from proactive items lacking this formal similarity, but the failure to find any difference may have arisen from the large amount of interference already present.

425. Wickens, D. D. & Simpson, C. K. Trace cue position, motivation, and short-term memory. Journal of Experimental Psychology, 1968, 76, 282-285.

Three different incentive conditions, 5¢ or 1¢ for a correct response, or a shock for an incorrect response were cued by varying the color background of the trigram slide (trace formation), number slide (trace storage), or recall slide (trace utilization) of the short-term memory sequence. The 48 Ss in each of the trace cue position groups received all incentive cues. The interpolated activity, counting backward by 3's, was measured. The motivational manipulation was significant only in the trace formation condition. A concomitant difference in the counting task supported the conclusion that differential rehearsal accounts for the motivational result.

426. Williams, J. R. & Fish, D. L. Effect of item length and number of different elements on immediate memory. Psychonomic Science, 1965, 3, 353-354.

Six Ss were tested for immediate memory on number and symbol items under conditions representing all possible combinations of 2 through 9 item lengths and 2 through 9 different elements. The items (symbol or number) were presented sequentially on a memory drum (the symbols for 3 sec. and the numbers for 1.5 sec.) and S recorded what he remembered immediately after the item disappeared from view. The results indicated that short-term retention decreases as the item length increases or as the number of different elements in the item increases.

427. Winnick, W. A. & Nachbar, S. Tachistoscopic recognition thresholds following paired-associate learning. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 95-100.

In three experiments, PA learning was followed by the measurement of tachistoscopic thresholds for the stimulus and the response words, as well as for control words not used in the learning. In all experiments, response words had significantly lower thresholds than did stimulus words. The variable of word frequency was found in the first experiment to affect control words more than the other words; furthermore, the contrast in thresholds for low and high frequencies was greater for stimulus words than for response words. Amount of S-R similarity was found, in Exp. II, to affect thresholds of stimulus words slightly more than thresholds of response words. In Exp. III, the amount of PA learning (50%, 100%, and 150% criterion) exerted little influence on the recognition of the stimulus items; the response items exhibited a lowering of thresholds from the 50% to the 100% groups and a rise in threshold for the 150% criterion group.

428. Woodhead, M. M. Simple rehearsal strategies for short-term recall. Psychonomic Science, 1966, 6, 385-386.

Four separate groups of Ss were assigned differing rehearsal strategies by which to memorize the randomized words of a sentence in the orders presented. Ss made less errors in recall after vocal rehearsal than after non-vocal. Reading

the words aloud twice without increasing the presentation time did not appear to delay the decay of the memory trace. Duplicated vocal and silent rehearsals appeared to have undefined intermediate roles.

429. Woodhead, M. M. Varying the number of alternatives in short-term recall. British Journal of Psychology, 1966, 57, 42-52.

Performance on a task of continuing memory span improved as the number of alternative items increased, in contrast to short-term recall from single presentations. The tentative explanation offered is that the difficulty of organizing items in chunks during continuing recall increases as the amount of information decreases.

430. Wright, J. H. Effects of formal interitem similarity and length of retention interval on proactive inhibition of short-term memory. Journal of Experimental Psychology, 1967, 75, 386-395.

Twenty Ss were randomly assigned to each of the 12 experimental conditions defined by the individual testing for STM of 6 CCC trigrams sharing 0, 1, 2, or 3 consonants under a 3-sec., 9-sec., or 18-sec. retention interval. Increasing the length of retention interval reduced the likelihood of recalling the consonants of a trigram and also increased STM recall latency. Increasing the similarity of prior test items reduced the likelihood of recalling the consonants of a trigram in their correct trigram-letter positions. Prior-item intrusions at STM recall were an increasing function of interitem similarity but were unrelated to the length of retention interval. These findings suggested that interitem similarity was detrimental to the storage of a later item for STM through a process of interitem associative interference and that the increasing length of retention interval provided increasing time for forgetting via memory-trace decay.

Y

431. Yntema, D. B. Keeping track of several things at once. Human Factors, 1963, 7-17.

A series of experiments on short-term memory is summarized. The results imply that when possible the following rules should be observed in presenting information to an operator who must keep track of a changing situation: (a) Each variable of which he must keep track should have its own exclusive set of possible states. (b) There should be few variables with many possible states, not many variables with few states. (c) A variable should not change state any more often than necessary. Three other conclusions may be useful to system designers as background information: capacity for random information is low; regularity within the sequence of states assumed by an individual variable is not particularly helpful; and orderly relations among the present states of different variables can be very helpful, at least in the extreme cases that were considered.

432. Yntema, D. B. & Mueser, G. E. Remembering the present states of a number of variables. Journal of Experimental Psychology, 1960, 60, 18-22.

The task was to remember the present states of 2, 3, 4, 6, or 8 variables. The S was read a series of messages, each saying what state one of the variables had assumed. He recorded the messages on a board on which the space for each variable was covered by a door that was open only while messages about that variable were being posted. The series of messages was interrupted at random by questions, each asking what was behind one of the doors. In one case (called the one-attribute case), all variables had the same set of four possible states; in the other (called the many-attribute case), each variable had its own exclusive set of four states.

The fraction of the questions answered correctly decreased as the number of variables increased and, if there were more than two variables, was lower when they all had the same set of four possible states. The probability that a particular question would be answered correctly depended on the number of questions and messages intervening between the question under consideration and the message that determined the correct answer.

433. Yntema, D. B. & Mueser, G. E. Keeping track of variables that have few or many states. Journal of Experimental Psychology, 1962, 63, 391-395.

The task was to remember the present states of several variables. The S was read a series of messages, each telling him what the state of one of the variables was. He recorded the messages in such a way that he could not see them once he had written them. At random intervals the series of messages was interrupted and he was asked to recall what the last message about one of the variables had been.

The effect of the number of states that each variable might assume was examined in seven cases that differed from each other in one or more of the following ways: (a) there were three variables for S to keep track of at once, or there were six; (b) all variables had the same set of possible states, or each had its own distinct set of states; and (c) the probability that a message would change the state of a variable was one, or it was one-fourth. In none of the seven cases did the number of alternative states have any significant effect on the fraction of the questions answered correctly, provided the fraction correct was adjusted for chance success. The probability of change was found to have a large effect.

434. Yntema, D. B. & Schulman, G. M. Response selection in keeping track of several things at once. Acta Psychologica, 1967, 27, 316-324.

Keeping track of the current states of several variables has been found to be more difficult when the states of all variables are drawn from the same category than when the states of different variables are drawn from different categories. The present experiment rejected some alternative explanations and concluded that S's superior performance in the case of different categories may be ascribed entirely to response selection: when there are different categories, he can sometimes dismiss a tentative response as impossible. Harris' Discriminant Rule was found to give an adequate quantitative description of the effect of constraining S's response in this way.

Z

435. Zeigler, B. P. & Sheridan, T. B. Human use of short term memory in processing information on a console. Technical Documentary Report No. ESD-TDR-64-620, USAF, Electronic Systems Division, L. G. Hanscom Field, Bedford, Massachusetts.

This report assumed that an operator's console constitutes a third form of memory in addition to that integral to the human and that integral to the machine which is not directly accessible to the human. Questions are raised concerning the characteristic modes of human storage and retrieval of information from internal memory when such external memory is accessible.

The report also introduces the concept of associative memory nets formed by cue-related images of external events. Information loss occurs when cues, originally capable of providing access to images, become insufficient to direct retrieval, in subsequent memory growth.

A list processing experiment is described. The processing involves adding or removing sequentially presented "items" (alphanumeric characters) from a list of previously processed items. Two conditions are established in which items are (1) presented directly, or (2) computed from presented data.

Storage structures characterizing internal human memory and external console memory in this task are postulated. A retrieval model implied by these structures is constructed to account for the effects of computation and learning upon the features of the experimentally obtained curves. Insufficient retrieval of required information from internal memory is assumed to necessitate external memory search. The effect of computation is to increase the probability of insufficient retrieval and hence the frequency of external search. Learning decreases this probability found generally to result in increased storage and retrieval times. Implications for console design are discussed.

INDEX

- Abstractness, 24, 121
Acoustic,
 confusions, 57, 117, 157, 289, 293, 304
 similarity, 12, 47, 60, 63, 86, 179, 185, 296, 411, 414
Activity trace, 54, 116, 151
 structured, 151
Acquisition, 301, 315
Affects, 164
Aftereffects, 314
After image, 210, 375, 376, 393
Age factors, 113, 357, 384, 385, 386
Amount of material, 2, 47, 93, 107, 116, 135, 155, 185, 196, 205, 206, 207, 210,
 212, 215, 226, 230, 231, 232, 242, 252, 256, 257, 258, 259, 260, 261, 265, 273,
 274, 275, 277, 278, 319, 325, 326, 340, 342, 356, 365, 366, 367, 373, 376, 381,
 383, 385, 387, 389, 391, 422, 426, 428, 431, 432, 433, 434
Anticipation, 17
Arousal, 404, 409
Association, 11, 47, 92, 127, 140, 355, 360
Associative factors, 38
 memory, 305 (see also Associative theory)
 symmetry, 141, 142, 281, 289, 356
Attention, 123, 129, 220, 224, 288, 312
Attributes, 28, 129, 131, 340 (see also Characteristics of stimuli)
Auditory stimuli, 69, 102
Availability
 cues, 186
 of information, 118, 141, 399, 407
 of response, 84, 85, 140

Binocular rivalry, 350

Capacity, 2, 8, 9, 58, 60, 299, 302, 329, 334, 335, 348, 367, 373, 391, 404, 410,
 431, (see also Channel capacity)
Categorization, 50, 51, 107, 203, 261, 344, 383, 387, 391, 392, 434 (see also
 Coding and organization)
Channel capacity, 60, 256, 264, 265, 266, 267, 282, 284, 302
Characteristics of stimuli, 27, 28, 30
Coding, 6, 10, 28, 34, 44, 86, 115, 116, 123, 124, 129, 136, 137, 149, 157, 173,
 186, 189, 190, 191, 192, 193, 197, 215, 225, 238, 249, 257, 258, 259, 260, 276,
 304, 320, 321, 342, 354, 355, 359, 362, 373, 377, 385, 386, 388, 394, 396, 402,
 412, 417, 425, 429 (see also Categorization and organization)
Compatibility of S-R, 11, 58, 130
Complexity, 299
 stimulus, 48, 190
 task, 171

Concept dominance, 353, 354
Concept formation, 221
Consolidation, 146, 148, 416
Construction hypothesis, 183, 184
Context, 292
Contextual constraint, 146, 184, 200
Criterion change, 96, 205, 222, 286, 292
Cues, 4, 74, 164, 185, 190, 191, 193, 257, 260, 298, 314, 318, 350, 354, 355, 376, 379, 381, 382, 383, 410, 422
Cultural primaries, 21

Decay, 3, 8, 9, 33, 34, 35, 59, 62, 66, 67, 98, 102, 113, 133, 208, 213, 214, 263, 295, 329, 331, 406, 421, 430 (see also Theory, decay)

Decision, 216, 301

Delay, 4, 47, 100, 104, 127, 159, 165, 167, 168, 169, 223, 324, 325, 368

Density, 391, 392

Detection, 122, 209, 383

Dial, 56

Dimensionality, 402

Display characteristics, 11, 149
complexity, 210
size, 111
time, 207, 230, 231, 232, 237

Distinctive features,
consonants, 412, 417
vowels, 412, 417

Duration,
exposure, 1, 118, 119, 166, 187, 210, 211, 227, 230, 231, 252, 349, 373, 383, 386, 392, 393, 416
message, 207, 211, 212, 213

Erasure, 8, 9, 298 (see also Masking)

Equivalent measures, 122

Familiarity, 201, 208, 226, 369, 390

Feedback, 165, 166, 167, 168, 169
delayed, 290

Filter, 106

Forgetting, 33, 34, 35, 77, 135, 170, 171, 172, 202, 276, 278, 292, 308, 315
mechanism, 333, 334, 335, 370
processes, 388, 403, 406, 411, 417, 430 (see also Interference and inhibition)

Forced choice test, 368

Frequency of use, 11, 83, 84, 93, 105, 107, 108, 121, 133, 147, 170, 172, 175, 177, 183, 195, 198, 203, 209, 224, 227, 228, 229, 233, 234, 235, 236, 239, 243, 244, 245, 317, 346, 349, 353, 355, 397, 427

Frequency-tables, 234, 243, 244, 245

Guessing, 27, 28, 135, 310

Hypnotic control, 109

Impairment of stimulus, 41

Incentive, (see also motivation)

 position, 382

 value, 382, 383, 390

Information,

 irrelevant, 224, 259, 298, 341

 relevant, 224

Information transformation, 335

Information processing, 2, 9, 10, 28, 34, 58, 63, 91, 107, 108, 155, 178, 256, 264, 265, 266, 267, 268, 272, 273, 282, 290, 292, 302, 330, 332, 333, 334, 352, 371, 390, 391, 392, 435 (see Theory, information)

Inhibition, (see also Forgetting and interference)

 conditioned, 112

 general, 166

 reactive, 112

I.Q., 22

Intelligibility, 88, 346

Intensity, 52

Interference, (see also Forgetting and inhibition)

 effects, 22, 59

 general, 144, 147, 148, 189, 213, 232, 259, 263, 276, 279, 289, 295, 332, 333, 337, 339, 342, 346, 357, 358, 359, 360, 361, 368, 385, 395, 396, 401, 403, 416, 418, 419

 proactive, 22, 23, 24, 26, 96, 158, 202, 203, 204, 236, 262, 267, 276, 277, 280, 306, 311, 326, 333, 363, 364, 400, 403, 419, 424, 430

 retroactive, 15, 26, 104, 236, 277, 342, 359, 416, 419, 420

 sources, 21, 59

Inter-item time, 130 (see also Intertrial interval)

 positive, 203

Interpolated activity, 16, 29, 36, 37, 64, 80, 81, 98, 109, 128, 135, 220, 255, 276, 279, 284, 287, 299, 307, 333, 334, 335, 337, 339, 342, 358, 370, 371, 374, 381, 396, 408, 409, 425 (see also Intervening items)

Intertest interval, 311, 313

Intertrial interval, 98, 101, 204, 252, 262, 318

Intervening items, 29, 98, 109 (see also Interpolated activity)

Intra-list differences, 144, 148

Intrusions, 344, 411, 412, 415

Keeping track, 257, 258, 259, 260, 261, 271, 325, 338, 431, 432, 433, 434

Keyboards, 58

Language-semantics,
 frequency, 61
 habit, 11, 61
 interlingual facilitation, 175
 mediators, 19
 similarity, 12, 15
 structure, 39
 symmetry, 141, 142
Learning, 17, 97, 183, 221, 246, 248, 249, 250, 251, 275, 278, 308, 315, 336, 341, 347, 382, 395, 396, 401, 404, 427
Letter sequences, 10, 12, 13, 14
Letter structure, 12, 13
Loudness, 294
Luminance summation, 99, 210
 effect of, 159

Masking, 88, 99, 100, 103, 104, 346, 371, 375 (see also Aftereffects)
Matrix, 5, 7, 223, 224, 227, 228, 362
Meaning, 127
Meaningfulness, 11, 24, 163, 165, 166, 167, 168, 169, 186, 189, 190, 191, 193, 247, 299, 328, 346, 355, 397, 401
Mechanisms, 35
Mediation, 353, 352
Memory processes, 1, 6, 38, 114, 132, 141, 143, 151, 171, 177, 178, 217, 242, 246, 263, 264, 266, 267, 269, 308, 309, 328, 345, 351, 363, 364, 377, 378, 435
Memory span, 20, 25, 33, 63, 76, 78, 90, 113, 176, 178, 186, 200, 205, 208, 217, 222, 268, 324, 326, 348, 388, 405
Memory trace, 3, 33, 34, 35, 38, 46, 90, 129, 164, 187, 303, 357, 359, 370, 407, 409, 416, 425, 430 (see also storage)
Method, 42, 158, 161 (see also Techniques of study)
 evaluation, 327
 measurement, 247
 ordering of stimuli, 300
Models, 150
 fixed point, 291
 information processing, 264
 partial learning, 250
 repeated measures, 306
Mode of presentation, 12, 38, 55, 66, 65, 67, 68, 70, 79, 81, 83, 95, 102, 125, 151, 185, 192, 211, 215, 218, 220, 263, 265, 266, 267, 268, 275, 281, 285, 288, 301, 302, 334, 350, 377, 413
Motivation, 164, 196, 248, 407, 408, 409, 410, 425 (see also Incentive and payoff value)
Motor responses, 3

Operating characteristic, 303
Ordering, 183
Order of recall, 38, 331, 385
Organization, 2, 38, 94, 115, 178, 214, 225, 227, 228, 257, 347, 354, 360, 371, 385, 386, 397, 422 (see also Coding)

Paired associate, 29, 140, 154, 160, 163, 226, 232, 247, 278, 279, 280, 281, 282, 283, 284, 286, 287, 288, 292, 307, 308, 309, 310, 312, 316, 344, 395, 396, 427
Payoff value, 196, 273, 274 (see also Motivation and incentive)
Post response stimulus duration, 98
Practice, 280, 289, 347, 352, 403
 effects, 23, 36, 172, 173, 203
 types, 23
 distributed, 160, 203
 massed, 203
Predictability, 14
Primary memory, 89, 406
Pronunciation, 192

Ranschburg phenomenon, 82
Rate of presentation, 45, 47, 60, 68, 105, 113, 134, 144, 162, 185, 186, 206, 211, 212, 214, 230, 231, 237, 240, 241, 242, 252, 257, 258, 259, 260, 261, 263, 265, 268, 275, 277, 278, 282, 294, 295, 301, 324, 331, 338, 345, 366, 372, 373, 375, 376, 377, 378, 379, 383, 384, 385, 387, 389
Rate of response, 208
Ratings, 323, 327
Reaction time, 269, 270, 271, 339, 341, 352, 380
Recency effects, 289, 316, 317, 319, 344, 395
Redundancy, 10, 34, 56, 73, 87, 89, 111, 389
Rehearsal, 19, 52, 53, 66, 67, 109, 124, 136, 144, 146, 148, 186, 188, 212, 255, 257, 258, 259, 260, 261, 295, 297, 315, 335, 338, 351, 377, 378, 382, 388, 406, 408, 409, 422, 425, 428
Reinforcement --amount of, 3
Reminiscence, 112, 163, 307
Repetition, 83, 90, 170, 172, 175
Repression, 408
Response,
 paced, 210, 349
 unpaced, 210, 349
Response bias, 374
Retrieval, 38, 41, 42, 43, 44, 45, 184, 217, 232, 251, 291, 298, 319, 362, 380, 398, 399, 407, 409, 419, 435 (see also Storage and memory trace)
Review, 20, 30, 31, 32, 336, 348, 361, 371, 406
 short-term memory, 289, 308

Scaling, 179, 180, 181
Scanning, 40, 71, 155, 217, 341, 377, 378
Sequential tasks, 14, 16, 94, 105, 106, 108, 118, 119, 138, 139, 194, 195, 196, 197, 198, 199, 200, 229, 240, 241, 242, 257, 258, 259, 260, 261, 320, 321, 329, 330, 338, 372, 387, 394, 431, 432, 433, 434
Serial position, 39, 90
 effects, 94, 130, 144, 152, 153, 174, 238, 269, 277, 280, 286, 292, 296, 307, 316, 317, 319, 344, 358, 395, 405, 422, 423
Serial task, 41, 42, 43, 44, 45, 144, 145, 205, 252, 267
Set, 38
 instructional, 16, 18, 97, 123, 125, 248, 255, 360
 response, 149, 380
Shadowing, 182, 314
Shift "rehearsal", 221, 338
Similarity,
 digits, 418
 item, 424, 427, 430
 phonems, 414, 419, 420
Spatial factors, 227, 228, 240, 241, 242, 257, 265, 269, 362
Speech, 296 (see also Language)
Steady state tasks, 368, 369, 370
Storage, 8, 9, 35, 41, 42, 43, 44, 45, 46, 83, 102, 110, 116, 129, 146, 147, 149, 151, 159, 164, 184, 185, 194, 195, 197, 199, 200, 201, 210, 217, 220, 226, 232, 233, 235, 251, 263, 285, 288, 289, 290, 292, 293, 314, 319, 335, 342, 343, 351, 352, 353, 375, 376, 377, 378, 383, 398, 404, 406, 410, 425, 435
Strategies, 16, 38, 95, 119, 124, 129, 136, 428 (see also Organization and coding)
Structures, 362
Syntax, 360 (see also Language)

Techniques of study-methods, 31
 distractor, 286, 287, 288, 289, 293
 probe, 286, 287, 288, 289, 292
Temporal factors, 1, 29, 38, 45, 99, 114, 146, 153, 154, 237, 238, 269, 285, 302, 349, 354, 357, 364, 404, 406
Theory,
 associative, 415, 418, 419, 420, 421
 decay, 33, 276, 295, 359, 361
 filter, 220, 263
 general short-term memory, 253, 254
 information, 256, 264, 320
 interference, 359
 memory span, 33
 perseveration consolidation, 404
 signal-detection, 122, 283, 286, 421
 storage, 220
 three factor of reminiscence, 112
 trace, 33, 35, 120
 verbal loop, 115

Threshold, 427
Transfer, 11
Transposition, 74
Type of material, 6, 42, 44, 45, 205, 210, 211, 212, 213, 215, 224, 229, 233, 235,
242, 256, 257, 258, 259, 260, 275, 301, 303, 310, 367, 378, 381, 408, 412, 426
Uncertainty, 362
Verbal context, 127 (see also Language)
Visual field, 78
Visual,
 confusion, 117, 157
 similarity, 47, 83, 156, 180, 181, 187
Vividness, 397
Von Restorff effect, 247, 270

Security Classification		
DOCUMENT CONTROL DATA - P & D		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author)		2a. REPORT SECURITY CLASSIFICATION Unclassified
U. S. Army Human Engineering Laboratories Aberdeen Proving Ground, Maryland 21005		2b. GROUP
3. REPORT TITLE SHORT-TERM MEMORY: AN ANNOTATED BIBLIOGRAPHY		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)		
5. AUTHOR(S) (First name, middle initial, last name) Dennis F. Fisher Harry F. Wiggins		
6. REPORT DATE August 1968	7a. TOTAL NO. OF PAGES 147	7b. NO. OF REFS 0
8a. CONTRACT OR GRANT NO.	8b. ORIGINATOR'S REPORT NUMBER(S)	
8c. PROJECT NO.	8d. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
c. d.		
10. DISTRIBUTION STATEMENT This document has been approved for public release and sale; its distribution is unlimited. Released to Department of Commerce for sale to the public.		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY	
13. ABSTRACT The bibliography is an annotated compilation of 435 references dealing with short-term memory. The period of time from 1959 to June 1968 (present) has accounted for the majority of research in this area, and in accord with this, most of the references included herein are from this period. The included references are arranged in alphabetical order by author. An alphabetical index of pertinent parameters of investigation as well as topics of interest is also provided.		

DD FORM 1 NOV 64 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS
OBsolete FOR ARMY USE.

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Short-term memory bibliography						

Security Classification